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POLLUTION OF THE NATURAL ENVIRONMENT WITH LEAD AND FLUORINE COMPOUNDS AT STRONIE ŚLĄSKIE IN THE YEARS 1974 AND 1975

(Stan zagrożenia środowiska naturalnego związkami ołowiu i fluoru w Stroniu Śląskim w latach 1974 i 1975)

Dust concentration and the fluorine and lead compounds content were determined in the air in the area of Stronie Śląskie, and at workplaces in the "Violetta" Lead Glass Glassworks situated within the urban area. Concentration of these pollutants was also determined in the water of the Białka River that flows through the city, and which is polluted with the effluents discharged from the glassworks. The toxic compounds were found in high concentrations in the air and in water, and a high annual increase in their concentration was observed.

Intensified production, increased consumption, accelerated urbanization and population growth account for a high rise in the hazard to the natural environment. The intensity and extension of the influence of industrial civilization upon the environment, which approaches the threshold of irreversible changes in the biosphere, as well as the vision of depletion of natural resources over a period of the lifetime of a few generations, darken the horizons for the development and biological existence of the mankind. Under these conditions much emphasis is being placed today to fill the technological gap in the domain of the environment pollution control and its associated basic research. Governments of a number of countries have set up a system of administrative and economic measures, along with the development of the environment conservation program and monitoring networks to measure pollution. The worldwide range of the environment pollution problems has called for the need of coordination of the effort and the necessity to overtake the isolationist trends.

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The endangerment of the natural environment in Poland stays in general on a medium level; locally, however, it assumes emergency conditions. Major share in pollution of the environment is due to particulate emissions, gaseous and liquid effluents associated with manufacturing processes. Emission rate of dusts and toxic gases nationwide is estimated at about three million tons annually. The quantity includes nontoxic dusts, carbon mono- and dioxides, sulfur dioxide, oxides of nitrogen, fluorine compounds, and lead with its compounds [3], [7], [9]. These substances have an adverse influence on human organisms, animals, and plants. They also bring about soil erosion, increased incidence of fogs, decreased ultraviolet radiation, or increased corrosion rate.

Maximum allowable 24-hr average concentrations for some airborne materials in the atmospheric air, in mg/m^3 under standard conditions, are as follows:

— sulfur dioxide — 0.35,
— nitrogen oxide (as N_2O_5) — 0.2,
— fluorine and its water-soluble compounds — 0.01,
— lead and its air-suspended compounds — 0.001,
— nontoxic dust — 0.2.

The quantity of sewage and liquid effluents disposed of to surface waters in Poland in 1966 was 6.4 billion cubic meters, an 11% of the average annual runoff. As a result, there is a progressing process of deoxygenation of waters, reduction of their biological capacity and restriction of their self-cleaning processes. The majority of pollutants have a toxic effect that poses a threat to biological life in rivers and lakes, as well as to direct consumers of water. Among this kind of pollutants rank compounds of such metals as lead, zinc, copper, chromium, cadmium, and nickel, also phenols, cyanides, and pesticides [4].

The ability to accumulate lead compounds in living organisms makes even low concentration of these compounds in the surroundings hazardous. The studies made allowed to establish the maximum allowable lead content at a level of 0.1 mg/dm^3 in drinking water, 0.05 mg/m^3 in the air by a workplace, and 0.001 mg/m^3 in the atmospheric air over inhabited areas [2].

The growing motorization, as well as development of such industries as electronics, chemical, metallurgical and ceramic ones, result in the rise in the emission of lead compounds [1], [5], [8], [11].

Undergraduate Chemists Group at Wrocław School of Economics has been engaged for several years in research on pollution of the natural environment of man. The body of problems included in the study presented here was concerned with the lead pollution of the air and of waters of the health resorts and spas of the Lower Silesia in the area of which lead

glass glassworks are located. In years 1974 and 1975 scientific field camps were organized at Stronie Śląskie. The choice of the site was due to the fact that the locality was designed for development as a health resort, and that nearby a large lead glass glassworks is operating, which uses lead compounds, thus, it is a lead emitter both to the atmosphere and to water [9]. In an effort for an integrated description of the environment pollution in that area, in 1975 the study program was extended by inclusion of the determination of fluorine concentration in water and in the air, and measurement of dust concentration in the air.

The air sampling technique consisted in allowing a definite volume of air to pass through a train of absorbers. Lead compounds were absorbed in a 0.2N nitric acid, and hydrogen fluoride in 0.2N sodium hydroxide solution. Lead was determined by a modified dithizone method [12], while hydrogen fluoride was analyzed by titration with a 0.001N thorium nitrate solution [7]. The sampling sites shown in Fig. 1 were as follows:

X_1 — on the sidewalk about 100 m in front of the main gate of the glassworks,

X_2 — at Kościuszko Street,

X_3 — by the Elementary School,

X_4 — near railroad station,

O_1 — behind the works on the premises of the kindergarten,

O_2 — by the department store,

O_3 — on the premises of the hospital,

O_4 — by the exit from Mickiewicz Street.

On the basis of the results obtained it was found that the lead content in the air of the locality of Stronie Śląskie has exceeded the allowable standards. The standards were exceeded eight to thirteen times (cf. Table 1). The lead concentration values were higher over the previous year for the same measurement sites. The remarkable rise in lead concentration at sites X_1, X_2, O_2, that amounts to a few hundred percent over the previous year, is due to changed direction of winds that took place

Table 1

Mean 24-hr Concentration of Lead Compounds in the Air at Stronie Śląskie in Years 1974 and 1975, $\mu g/m^3$ (STP)

Sampling site	Concentration of lead compounds		Sampling site	Concentration of lead compounds	
	1974	1975		1974	1975
X_1	2.14	9.58	O_1	6.28	7.60
X_2	1.76	13.55	O_2	2.70	7.66
X_3	1.78	—	O_3	5.16	—
X_4	7.11	9.52	O_4	8.06	8.49

in that period. In 1974 the prevalent winds came from northwest and northeast, whereas in the subsequent year the air movements were featured by considerable variability with a trend to stay on the northeast and southeast direction.

The effect of wind direction on the values of lead concentration in the air is best illustrated by the results obtained in the first day of the measurements at sites O_1 and X_1. At that time the wind blew till 12:00 toward site X_1, thus from the works, and lead concentrations were high

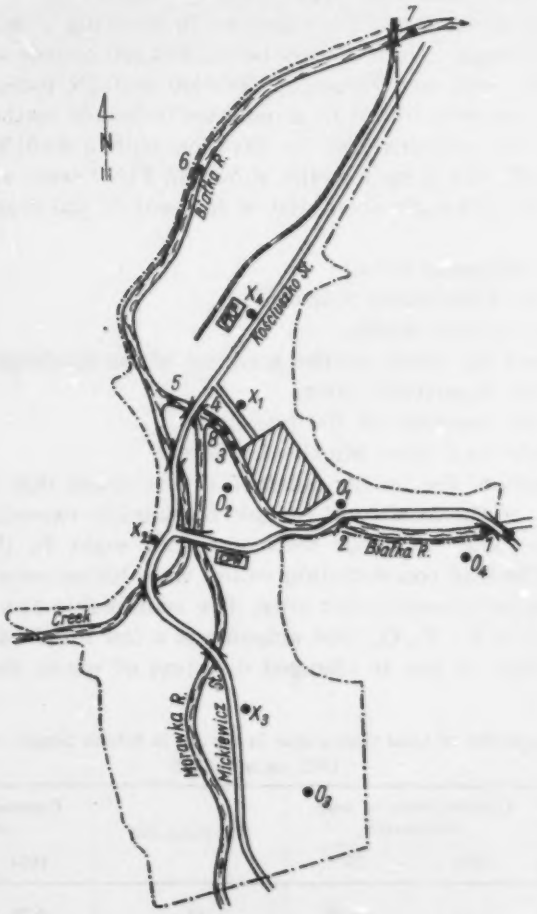

Fig. 1. City plan of Stronie Śląskie: shaded area — the glassworks; CPN — gas station; other letter symbols are defined in the text; the numerical symbols are explained in Tables 5 and 6.

to exceed on average 13 times the allowable standard. As the wind direction changed to the opposite, lead concentration dropped markedly at that measurement site to rise appreciably at site O_1 situated along the line of wind direction but opposite the glassworks (Table 2).

Table 2

Lead Concentration Distribution in the Air at Sampling Sites O_1 and X_2, $\mu g/m^3$ (STP)

No.	The time of sampling	Lead concentration in the air	
		X_1	O_1
1	8:00 a.m.–10:00 a.m.	10.00	2.02
2	10:00 a.m.–12:00	16.83	7.95
3	12:00–2:00 p.m.	3.14	10.62
4	2:00 p.m.–4:00 p.m.	4.70	—
5	4:00 p.m.–6:00 p.m.	2.97	11.15
6	6:00 p.m.–8:00 p.m.	17.06	6.28

Lead content in the air at the workplace in the glassworks measured exceeded only slightly the allowable standard which for newly built works is 50 $\mu g/m^3$ (STP), and merely in the vicinity of the tank furnace. In the surroundings of annealing furnaces, however, the standard was not exceeded. The data refer to the mean 24-hr concentration values. As concerns individual shifts the situation was as follows: the exceeded values occurred during shifts no. 2 and 3 for furnaces and during shift no. 2 at the entrance to annealing furnaces. Maximum values of the exceeded standards reached 50% of the allowable value. These relatively low lead concentrations are due to efficient exhaust system and to a screen of special design used to separate workplaces from the furnace charging department. Lead concentration in the air decreases with the distance from the furnace. This can be seen from the data of Table 3 which reports results of the measurements of the lead concentration distribution when

Table 3

Mean Concentration of Lead Compounds in the Air at a Workplace in the "Violetta" Glassworks for Individual Production Shifts, $\mu g/m^3$ (STP)

Date of sampling	Shift	Lead concentration	
		between tank furnaces	by the entrance to annealing furnaces
Aug. 7–8, 1975	1	45.03	37.82
	2	58.03	54.74
	3	58.11	31.91
	4	40.62	19.36
Average for 24 hr		50.45	36.01

sampling was made by the tank furnace and away from the furnace by the annealing furnaces.

Hydrogen fluoride content was also determined in the air at Stronie Śląskie and at workplaces in the "Violetta" Glassworks. For the atmospheric air the standard of 10 $\mu g/m^3$ (STP) was exceeded for each sample collected in the urban area (Table 4). The mean 24-hr concentration of hydrogen fluoride in the air at individual sampling sites exceeds the standard by three to five times. A relation has been established for the drop in hydrogen fluoride concentration with the distance from the glassworks for no-wind conditions.

Table 4

Mean 24-hr Concentration of Hydrogen Fluoride in the Air at Stronie Śląskie, $\mu g/m^3$ (STP)

No.	Sampling date	Sampling site	HF content	Sampling site	HF content
1	Aug. 4, 1975	X_1	36.65	O_1	44.44
2	Aug. 5, 1975	X_2	26.94	O_2	53.87
3	Aug. 6, 1975	X_4	51.31	O_4	47.12

In the etching department of the glassworks the standard set as 500 $\mu g/m^3$ (STP) was exceeded on average twofold and more. The rise in HF concentration occurred immediately after the acidic solution of fluoride salt was batched and when spent etchants were discharged from the vat to neutralizers.

Pollution of local waters was investigated on the example of the Białka River which is the recipient of liquid effluents from the glassworks. The samples were taken in the middle of the main river stream and at the mouth of the effluent discharge gutter. The water sampled was analyzed for the content of fluorine and lead compounds by the methods analogous to those used for the determination of these compounds in the air. The sampling sites marked in Fig. 1 are located as specified in Tables 5 and 6.

It was found that lead concentration in the Białka River upstream of the effluent discharge point did not exceed the allowable standard which for all the water quality classes is 0.1 mg/dm^3. Concentration of lead compounds was established to be about one fifth of the maximum allowable standard value. The situation is, however, entirely different downstream of the effluent discharge point. In the period the effluents were being discharged, lead concentration was over 400-fold higher than the allowable standard in the area of effluent discharging and eightfold — 50 m downstream of the discharge point. About 2000 m away from the discharge point, lead concentration exceeded the standard five-

Table 5

Lead Content in the Water of the Białka River, gm/dm³

Nos. in Fig. 1	Sampling site	Lead content		
		Aug. 3, 1974	Aug. 6, 1975	Aug. 12, 1975
1	On the Stronie Śląskie city limit	0.020	0.019	0.006
2	By the water intake for the glassworks	0.020	0.030	0.008
3	On the hydraulic jump near the glassworks water intake	0.035	0.010	0.009
4	50 m downstream of the effluent discharge point	0.960	0.832	1.980
5	50 m downstream of the Morawka R. mouth (tributary of the Białka R.)	0.035	0.027	0.071
6	1000 m downstream of the effluent discharge point	0.140	0.045	0.480
7	About 2000 m downstream of the effluent discharge point	0.100	0.044	0.520
8	At the effluent gutter mouth	7.800	43.600	0.026

Table 6

Concentration of Fluorine Compounds in the Water of the Białka River, mg/dm³

Nos. in Fig. 1	Sampling site	Fluorine concentration	
		Aug. 6, 1975	Aug. 12, 1975
1	On the Stronie Śląskie city limit	0.288	0.247
2	By the water intake for the glassworks	0.288	0.266
3	On the hydraulic jump near the glassworks water intake	0.177	0.209
4	50 m downstream of the effluent discharge point	0.454	4.104
5	50 m downstream of the Morawka R. mouth	0.304	0.361
6	1000 m downstream of the effluent discharge point	0.152	1.615
7	About 2000 m downstream of the effluent discharge point	0.342	3.325
8	At the effluent gutter mouth	6.422	8.056

fold. The decrease in lead concentration observed is likely due to the effect of dilution of the effluents with the masses of fresh water from the Morawka River and probable precipitating and settling of insoluble lead compounds in the riverbed. The scatter of the results obtained also depends on the periodicity of effluent discharges, which did not coincide

with the sampling periods. Consequently, concentration waves of lead compounds in water of the river were noted.

Concentration of fluorine compounds upstream of the effluent discharge point in the Białka R. waters was found to stay below the pollution standards which for the first and second water class are 1.5 mg/dm³ and for the third class 2 mg/dm³ (Table 6).

Likewise, fluorine ion concentration exhibited a time variation related to the periodicity of effluent discharge. Fluorine concentration at the discharge point exceeded the allowable standard about fivefold. The concentration was decreasing with the distance of the sampling site from the discharge point, attaining a twofold excess over the standard about 2 km from the point. A certain disturbances in the fluorine concentration is caused by the tributary of the Morawka R. which makes fluorine concentration fall abruptly.

Parallel to the air sampling program for the determination of fluorine and lead contents, dust concentration was measured on August 4, 5, and 6, 1975. Additionally measurements were made at night near the Municipal Hotel and in the daytime on August 7 and 8 of that year in the mechanical department and between tank furnaces of the glassworks. The sampling was made using an AZK-1 sampler and the determinations were performed with an RM-2 reflectometer. Dust concentration in the air was calculated on the basis of the British Standards Specification No. 1747.

The dust concentration determinations showed that the allowable standard of 0.2 mg/m³ (STP) was not exceeded (Table 7). The most serious dust pollution was noted in the daytime by busiest roads. The relation of dust pollution to vehicular traffic is unquestionable, as the pollution level during the night was one fourth of the daytime level. Likewise, at workplaces in the glassworks, both in mechanical department and near tank furnaces, dust concentration did not exceed the pollution standard which is 10 mg/m³. The highest dust concentrations measured were a mere 10% of the standard value. A periodicity in dust concentration can be observed, which may be due to occasional charging of feedstock to the furnace (Table 8).

Table 7

Mean 24-hr Dust Concentration in the Air at Stronie Śląskie, mg/m³ (STP)

No.	Sampling date	Sampling site	Dust concentration	Sampling site	Dust concentration
1	Aug. 4, 1975	X_1	0.046	O_1	0.021
2	Aug. 5, 1975	X_2	0.059	O_2	0.008
3	Aug. 6, 1975	X_4	0.026	O_4	0.019

Table 8

Dust Content in the Air in the Surroundings of the Municipal Hotel and at a Workplace in the "Violetta" Glassworks at Stronie Śląskie, mg/m³ (STP)

No.	Sampling date	Sampling site	Sampling time	Dust concentration
1	Aug. 4–5, 1975		10:00 p.m.–7 a.m.	0.018
2	Aug. 5–6, 1975	hotel	9:45 p.m.–7:25 a.m.	0.019
3	Aug. 6–7, 1975		9:00 p.m.–9:00 a.m.	0.027
4	Aug. 7, 1975	mechanical dept. of the glassworks	10:00 a.m.–2:00 p.m.	1.069
5	Aug. 7, 1975		2:40 p.m.–6:40 p.m.	0.034
6	Aug. 7, 1975		6:50 p.m.–10:50 p.m.	1.004
7	Aug. 7–8, 1975	by the furnace	10:55 p.m.–2:55 a.m.	0.086
8	Aug. 8, 1975		3:00 a.m.–7:00 a.m.	1.000
9	Aug. 8, 1975		7:05 a.m.–11:00 a.m.	0.096

The content of the toxic lead and fluorine compounds detected in the air and in water reflects the degree of the hazard to the urban area of Stronie Śląskie. An increase in water and air pollution over the previous year should be noted. Mean 24-hr lead concentration in the air sampled at the same points was higher by 2.15 times, being in one case eightfold. This is due to increased activity of the "Violetta" Glassworks situated within the urban area of Stronie Śląskie. In this connection it is of urgent importance to reduce emission of toxic compounds into both the atmosphere and water. This can be accomplished by adequate methods of waste gas and effluent treatment applied by the works.

An alternative could be another manufacturing process that does not require the use of lead or fluorine compounds. The existing conditions make Stronie Śląskie unsuitable as a health resort and tourist center, despite its attractive situation in the Śnieżnik Mt. area.

Some protection zones that would separate the glassworks from the urban area seem highly desirable. The present location of the kindergarten that is adjacent to the premises of the glassworks is inadmissible.

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MUNICIPAL REFUSE DISPOSAL BY INCINERATION

(Termiczne unieszkodliwianie odpadów komunalnych)

The problem of disposal of municipal refuse by incineration is discussed with emphasis on the air pollution control.

Rapid development of cities creates the problem of increased production of municipal waste. Dumping of the refuse fails to meet the sanitary conditions of the protection of natural environment of man, and it may also be a source of epidemics. The problem cannot be solved by covering the garbage layers with earth, proceeded by their treatment with disinfectant.

Newly developed settlements entail accumulation of refuse year by year. In the refuse produced increased quantities of cellulose packings and materials are observed, which raises their heating value. Municipal refuse, in view of their considerable content of organic matter, poses a hazard to waters, soil, and air, as well as to the health of animals and humans. At the same time, the unavailability of land suitable for dumping grounds prompts one to search for some efficient methods of refuse disposal.

Incineration is one of the most efficient techniques of waste disposal. This technique is increasingly used and developed in many countries. Of the advantages of this method are:

— in one plant not only garbage can be incinerated but also spent oils and sludge from sewage treatment units,

— waste does not require separation, preliminary treatment, or drying,

— incineration results in a complete annihilation of the substance, i.e., the substance is converted to gaseous component under the effect of heat.

It is important to know whether or not the combustion process may proceed on account of its own heat energy, or if some additional fuel must

be used because of high water or ash content in the waste. The temperature in the combustion chamber should not drop below 850°C, as otherwise the combustion process is bad, and the exhaust gases contain unacceptably high amounts of decomposed aromatic compounds that are a nuisance to the environment.

Municipal refuse is a material of variable chemical composition, as well as of nonuniform structure, which is a major factor for the combustion process. The heat of combustion of refuse is low and markedly variable. To maintain the temperature always above 850°C, additional mazout burners are provided in the combustion chamber, which go on automatically in case of emergency.

Of considerable significance for the combustion process are also the properties of slag and fly ash produced. As the softening and melting points of the ash produced on incineration of municipal refuse ranged from 1050 to 1150°C, higher temperatures should be avoided.

Layout of a typical municipal refuse incinerator is presented in Fig. 1. The garbage is brought to the incinerator premises by refuse collection trucks to be stored in special tanks, or in polyethylene bags by tipper trucks and unloaded to storage tanks. The storage tanks are provided with the equipment for opening and emptying of bags. The equipment

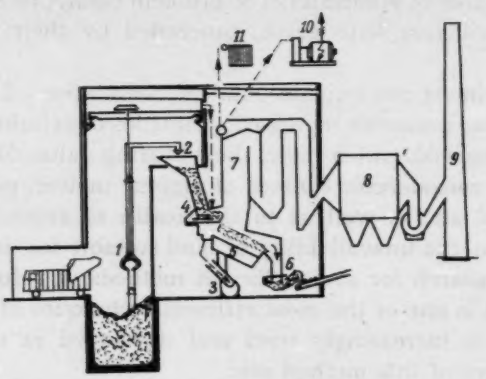

Fig. 1. A municipal refuse incinerator: *1* — clamshell grab; *2* — charging hopper; *3* — draft fan; *4* — pusher; *5* — underfeed stoker; *6* — ash remover; *7* — boiler; *8* — electrostatic precipitator; *9* — stack; *10* — electric power; *11* — warm water.

has also water sprays to prevent dusting. Hence refuse is delivered by means of a grab *1* to charging hopper *2*, wherefrom pusher *4* feeds it onto an underfeed stoker *5*. There refuse gets burned, and the air needed for the combustion process is delivered by draft fan *3*. Ash and slag are quenched with water in the ash remover *6* wherefrom it is subsequently

dumped. The heat of flue gases is recovered in boiler 7 in the form of warm water *11* or electric power *10*. Next, flue gases are fed to electrostatic precipitator *8* to precipitate dust. Draft fan pushes clean gases into the stack *9*.

Despitc that the incineration process so far is the most expensive method of waste disposal, it is the most efficient one. Table 1 reports performance data of municipal refuse incinerators operating in Hamburg, Stuttgart, Zurich and Chicago.

For dust precipitation from the flue gases produced in municipal refuse incinerators dry electrostatic precipitators are employed especially for high capacity units. The precipitators of that type are good to treat relatively highly polluted gases (up to 100 g/m³ and above) of a temperature up to 450°C from dusts of virtually any particle size composition. The gas purity achieved ranges 100 mg/m³.

The flue gas temperature can be lowered either in steam boilers (to use the heat of the flue gases to generate steam) or by water injection, or else by aspiration of cold air (in the plants without heat recovery).

The license purchased from Lurgi Company (Federal Republic of Germany) for the manufacture and designing of electrostatic precipitators permitted to start the production of these pollution control devices in the plants grouped in the "Klima-Went" Union. The units manufactured are single or multiple section two-, three-, or four-pole ones of a capacity ranging from a few thousands to a million cubic meters per hour of the gas treated. The performance characteristics of electrostatic precipitators for the municipal refuse incinerators are as follows:

— dust concentration range for the dirty gas 2–20 g/m³ (STP),

— dust concentration downstream of the precipitator 0.1 g/m³ (STP),

— electric power consumption to 0.3 kWh/1000 m³ (STP).

In Fig. 2 is shown a flow sheet for the pollution control installation of municipal refuse incinerator unit.

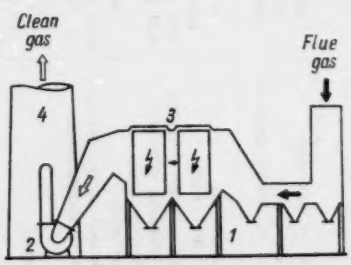

Fig. 2. Flow sheet of the municipal refuse incinerator pollution control plant: *1* — dust hoppers; *2* — exhaust fan; *3* — electric field; *4* — stack.

Performance Data for the Boiler Plants Adapted for Municipal Refuse Incineration — Table 1

Performance data of the plant	Unit	Location			
		Hamburg	Stuttgart	Zurich	Chicago
Capacity					
Boiler plant	ton/day	2360	480	264	1440
Rated calorific value of fuel	kcal/kg	1500	1200	3000	2500
Fuel calorific value range	kcal/kg	1500–2800	800–2200	1600–3300	1800–3300
Fuel tank capacity	m^3	7000	4000	no data	7400
Furnace					
Effective stoker area	m^2	43.9	50.45	44.9	50
Stoker width	m	4.91	6.02	5.57	5.6
Number of stoker elements	piece	17	17	15	17
Steam generation					
Steam yield, max	ton/hr	40	125	38.2	50.0
Maximum steam pressure	atm gauge	52	77	45	21.1
Steam working pressure	atm gauge	46.6	69		17.5
Superheated steam temperature	°C	410	525	420	saturated steam
Superheated steam pressure	atm gauge	41		37	
Fed water temperature	°C	135	180	150	107
Ash disposal		Martin's ash remover, trough conveyor, belt conveyor, magnetic separator, slag mill	Martin's ash remover, belt conveyor, slag mill, magnetic separator, and iron scrap compactor	Martin's ash remover, screw conveyor	Martin's ash remover, apron conveyor, 50-mm diameter drum screen
Gas treatment		electrostatic precipitator, cleaning of gases to 150 mg/m^3 (STP) at a 7% CO_2 content	electrostatic precipitator, cleaning of gases to 150 mg/m^3 (STP)	two-pole electrostatic precipitator, cleaning of gases to 0.075 mg/m^3 (STP)	two-pole electrostatic precipitator, cleaning of gases to 0.115 g/m^3 (STP) at 8.8% CO_2
Dust disposal		water-spray screw conveyor, Martin's ash remover		bucket conveyor, screw conveyor	scraper, water-spray screw conveyor, Martin's ash remover

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Cwynar, B.

THE EFFECT OF SULFUR DIOXIDE ON CORROSIVE PROPERTY OF THE ATMOSPHERIC AIR TOWARD SOME CHROMIUM STEEL GRADES AT VARIOUS RELATIVE HUMIDITY OF AIR

(Wpływ dwutlenku siarki na stopień zagrożenia niektórych stali chromowych przy różnych wilgotnościach względnych powietrza)

Results are reported from a study of the effect of average air humidity and the length of the periods of the humidity above 80% on the corrosiveness of the atmosphere containing SO_2 for four standard steel grades.

The problem of clean atmosphere is understandably viewed in the first place from the standpoint of conservation of the biological environment. The existing legislature pertaining to this subject is aimed toward that goal.

Much less attention is paid to the destructive influence of contaminated air upon materials in the evaluation of the adverse effects of gaseous and particulate emissions.

The importance of this problem, however, is best reflected by constantly growing expenditures for renovating work and for corrosion-preventing means which are needed to maintain the equipment and facilities operated under atmospheric conditions in full technical efficiency.

As shown by the early investigations by Vernon [1]–[3] and substantiated by laboratory tests of Skorchelletti et al. [4] and by the results obtained by a number of other students [5]–[9], the major reason for enhanced corrosive agency noted in urban and industrial atmospheres is the presence of sulfur dioxide there. The consensus is also as to the effect of water vapor in the destructive influence of SO_2-containing air [4].

The nature of surface processes occurring with participation of water and the kind of corrosion products were demonstrated by laboratory studies [8], [10], [11]–[13], and especially by X-ray studies by Schwarz [10], to depend upon the SO_2 concentration range and the quantity of

electrolyte present. Hence the potential aggressiveness of the atmosphere with a definite sulfur dioxide content depends upon saturation of the atmosphere with water vapor [2], [9].

Thus correct evaluation of the corrosion hazard due to the presence of this contaminant in the air and forecasting of the stability of structural materials require humidity relations typical of our climate to be taken into consideration. This can be achieved either by simulation of corrosive environments or by observations at properly selected experimental stations.

This article is concerned with the results of field experiments conducted at two experimental stations situated within the range of a point source of SO_2 emission which differed by the values of ground level concentrations of this pollutant. The aim of the study was to determine the effect of humidity of the air upon the intensity of the corrosive activity of the atmosphere containing varying amounts of SO_2.

Experimental

Materials Examined

Four steel grades of the composition indicated in Table 1 were included in the study. The samples were in the form of rectangular plates cut out of 5-mm sheet metal of an overall surface area of a single plate of 0.0088 m². To remove any possible residue of scale and to make the metal surface standardized, all samples were subjected to mechanical and chemical treatments prior to their exposure.

Mechanical treatment was achieved by means of magnetic polishing until a smoothness corresponding to class 7 after Polish Standard PN/M-04251.

Table 1

Specification of Chemical Composition of the Steel Grades Examined, %

Grade	C	Mn	Si	P	S	Cr	Ni
St3	0.22**	0.65**	0.12–0.30	0.05**	0.055**	—	—
OH13	0.08**	0.60**	0.60**	0.035**	0.03**	12.0 14.0	0.6**
H17	0.12**	0.70**	0.80**	0.035**	0.03**	16.0 18.0	0.6**
H6S2*	0.15**	0.7**	1.5–2.0	0.035**	0.03**	5.0 6.5	0.6**

*H6S2 steel belongs to scaling-resistant and heat-resistant materials, but because of some reports on its resistance to SO_2 it was included in the study.

**Maximum values.

Chemical treatment involved removal of the rust from the surface using a diluted standard soap solution prepared as specified in the annex 1 to Polish Standard PN-70/H-04682, subsequently diluted in a 1:1 ratio.

Immediately after the treatment, the samples were hanged on the racks of special design placed under a roof on the premises of the experimental stations.

Exposure Conditions

The experiments were carried out at the same time at two experimental stations situated at the same locality so that virtually identical meteorological conditions were ensured. Each station, however, represented diverse corrosive conditions in view of their unequal distance from the SO_2 point emission source. To obtain results for various meteorological conditions, a new 20-item sample lot was exposed every two months over a 24-month period for each of the materials studied. Every month three random samples were removed from individual lots and subjected to analysis. Thus the maximum exposure time was 180 days during which the material was examined sixfold.

The technique used allowed to follow the effect of various humidity relationships, in particular that of the length of the periods of a relative humidity above the critical value of 80% [9], on the corrosion rate of the materials examined.

The major variables of the corrosive environments were:

— relative humidity of the air,

— sulfur dioxide concentration in the atmosphere.

Values of the former variable were obtained from the measurements of the local weather station, where one of the experimental stations had been localized.

Analyses of the sulfur dioxide concentration in the air were conducted continuously by the contact method in conformity with the regulations in question [14]. The suitability of this method for the determination of sulfur dioxide concentration in the air for other purposes than corrosion studies was the subject of much controversy and was found unsatisfactory.

The main disadvantage of the lead dioxide method is considered to be the influence of weather conditions (temperature, wind speed) and the method of preparation of the cartridge on the rate of SO_2 reaction with PbO_2. As a result of periodical variations in the rate of this process, individual results exhibit a limited correlation compared with the results obtained by other measuring techniques.

The investigations made by Mac Adie and Jones [15] demonstrated, however, that in the case of a permanent localization of measuring stations, the correlation coefficients found for two various measuring techniques (lead dioxide and continuous measurement of SO_2 concentration by aspiration), even though not high, they are almost constant. To illustrate this finding, all annual correlation coefficients determined during the four-year period of the studies mentioned [15] were much alike and ranged from 0.42 to 0.59. The findings prove that for a definite area and its prevalent meteorological conditions, sulfur dioxide concentration can be measured with sufficient accuracy even by the lead dioxide method. Furthermore, the method in point, being more sensitive to the condition of the atmosphere, affords a better picture of conditions of contacting of SO_2 with the metal surface than any of the aspiration methods available.

Since for the corrosion studies the most significant is the possibility of the reaction of sulfur dioxide with the metal surface rather than an absolute SO_2 concentration, this method is also good in that the errors due to the effect of instantaneous variations in the external conditions on the transport rate of the gaseous reagent can be eliminated.

A serious drawback of the contact method, however, is that the share of individual sulfur-related air pollutants, especially sulfuric acid, in the overall quantity of sulfates determined cannot be measured. In view of a notable corrosive activity of this compound, it was necessary to verify if and in what amount sulfate ions are present in the atmosphere of the experimental stations. For this purpose the absorptive capacity of H_2SO_4 vapors on filter paper was used.

A similar material was successfully used for the absorption of acidic components of the atmosphere in the aspiration method of filter paper disks reported by Jacobs [16]. In this study for continuous absorption of sulfuric acid vapors a filter paper stripe was used saturated with 1% aqueous solution of formaldehyde with an addition of glycerol to prevent possible oxidation of trace SO_2 trapped. Subsequent determination of sulfate ions was performed by the turbidimetric method with the use of barium chloride as precipitant.

Results of the studies showed, however, that in the environment with a higher SO_2 concentration the presence of SO_4^{2-} derived from sulfuric acid and partly those from trapped sulfur-bearing particulates was not higher than 0.0002 mg SO_3/m^2 per 24 hr.

In the other environment examined sulfate ions were not found at all. Thus in the considerations of the results on corrosion rate it was assumed that under the conditions in point the only aggressive sulfur compound is SO_2.

Corrosion Rate

Corrosion rate was measured by means of gravimetric determinations of loss in weight of the samples preceded by the removal of corrosion products by treatment in the ammonium tartrate solution in conformity with the Polish Standard PN/H-04600.

Each time also chemical analysis of the products formed was made with the determination of the SO_4^{2-} ion content.*

In accordance with the general practice, the results related to the extension of corrosion were expressed in g/m², whereas corrosion rate was given in g/m² per 24 hr. Results obtained are illustrated graphically in a series of figures which for individual stations represent the following relations:

— corrosion vs. percentage of the time with relative humidity higher than 80%, in the case when the total exposure time was 30, 60, and 90 days, respectively,

— corrosion vs. total number of "humid" days at a given overall time,

— corrosion rate vs. average relative humidity over the 30-, 60-, and 90-day periods.

Merely the most characteristic graphs are reported in the paper.

The effect of the percent share of the days with relative humidity exceeding 80% on extension of corrosion of steel over definite time periods is shown in Figs. 1 and 2. Sulfur dioxide concentration is given everywhere as mg SO_3/100 cm² PbO_2 per 24 hr.

Generally the effect of humidity of the air on corrosion of steel depends upon concentration of sulfur dioxide in the atmosphere and upon the steel grade.

In the environment containing SO_2 in fairly considerable quantity (according to the measurement method assumed, above 0.001 mg SO_3/100 cm² PbO_2 per 24 hr) corrosion of all materials examined increases with the rise in the share of humid days (cf. Figs. 1*a* and 2*a*). The rate of corrosive destruction is different for individual steel grades. Moreover, it varies considerably depending upon whether the increased humidity days occur in the early or in the late period of the exposure. The most drastic variations in the corrosion resistance is noted in the common structural carbon steel grade St3.

Slight differences between corrosion values found for this material after 30, 60, and 90 days of exposure, in the periods of many (80%) humid

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*A detailed discussion of the results concerning sulfur fixation is given in the paper on The Resistance of Some Chromium Steel Grades in the Air Containing Sulfur Dioxide, *Rudy i Metale* (in press).

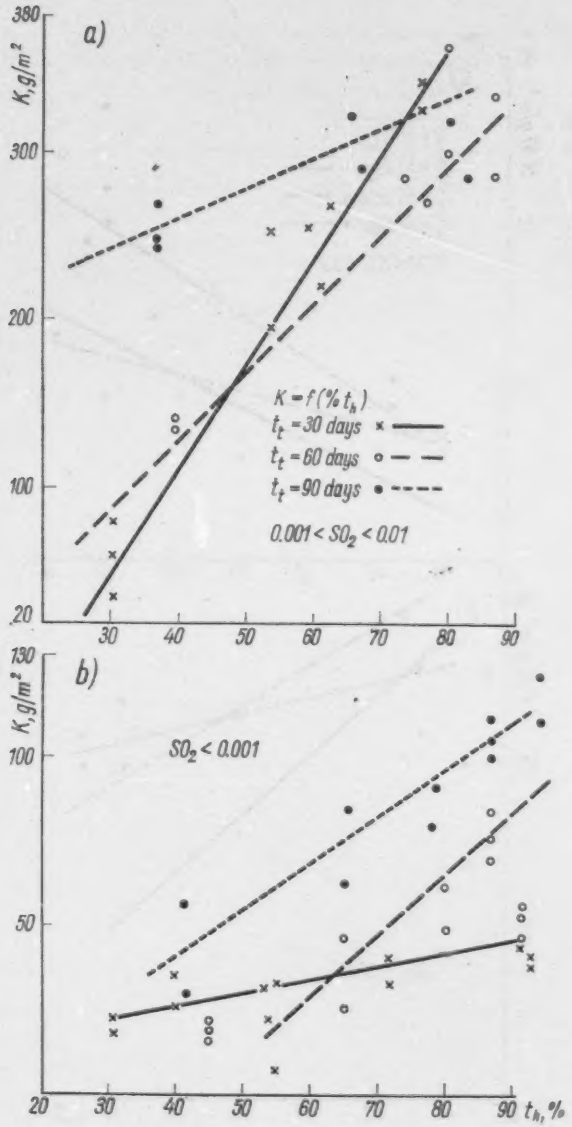

Fig. 1. Corrosion of St3 steel as a function of the percent share of humid days: *a* — environment 1; *b* — environment 2; t_h — humid days; t_t — total time.

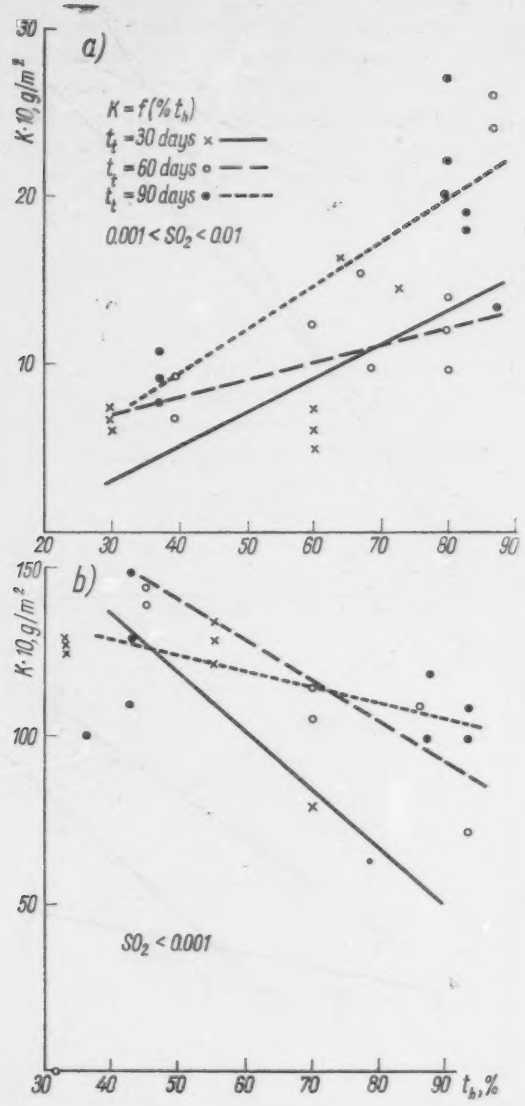

Fig. 2. Corrosion of OH13 steel as a function of the percent share of humid days. Denotations as in Fig. 1.

days indicate that this steel grade is the most susceptible to the effect of the environment in the initial period of the exposure.

More resistant in that corrosion stage is scaling-resistant H6S2 steel, for which the points of weight loss after 60 and 90 days lie above points determined for the 30-day period. A fairly proportional development of corrosion of that steel over the entire period of the exposure to the conditions in point indicates that however low the presence of sulfur dioxide still poses a corrosion hazard. Quite different behavior from that of common steel was observed for OH13 stainless steel (Fig. 2*a*).

While in the first days of exposure, likely on account of an oxide film present on the metal surface, the steel is fairly insensitive to the humidity relationships, in a later period corrosion is faster possibly because of the buildup of hygroscopic corrosion products.

Less clear is the behavior of H17 stainless steel. The results are similar for various exposure times and a close number of humid days. This can be explained in terms of a relatively low values of corrosion itself. Here also the effect of the nature of the surface, and especially of the thickness of its outermost layer rich in Cr_2O_3, is much more pronounced than for other grades. In the environment poorer in sulfur dioxide (the station located some 5 km from the emission source) the relationships under discussion are similar only for the first two steel grades. Corrosion grows with the share of humid days, particularly for St3 steel (Fig. 1*b*). For H6S2 steel, however, this relationship is no longer as unambiguous, as in the range of moderate values of that variable corrosion rate declines with time. Weight loss values after a 90-day exposure are therefore not much higher than for a 60-day exposure.

Clearly different is the behavior of OH13 steel (Fig. 2*b*), and H17 steel. The presence of humidity on the surface of these materials, resultant from sufficiently long "humid" periods, is likely to promote the formation of the resistant oxide layers which efficiently protect them against the environmental influence. This is in good agreement with earlier observations that the life of chromium steels is extended under conditions of frequent washing of their surface by rains.

The Exposure Time Effect

Figures 3*a* and 4*b* illustrate the relation between exposure time and corrosion of steel. The exposure time, however, was assumed after Beranek and Bartoň [9] as merely the days with air humidity above 80%. The results presented refer therefore to unlike times, which leads to a clear scatter of the points.

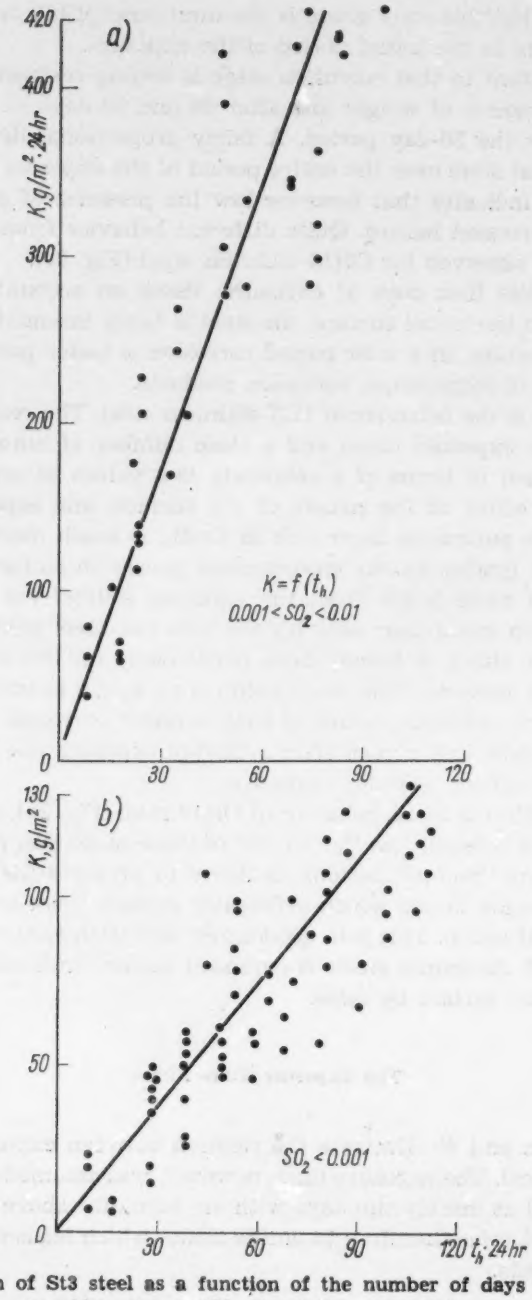

Fig. 3. Corrosion of St3 steel as a function of the number of days with a relative humidity above 80%. Denotations as in Fig. 1.

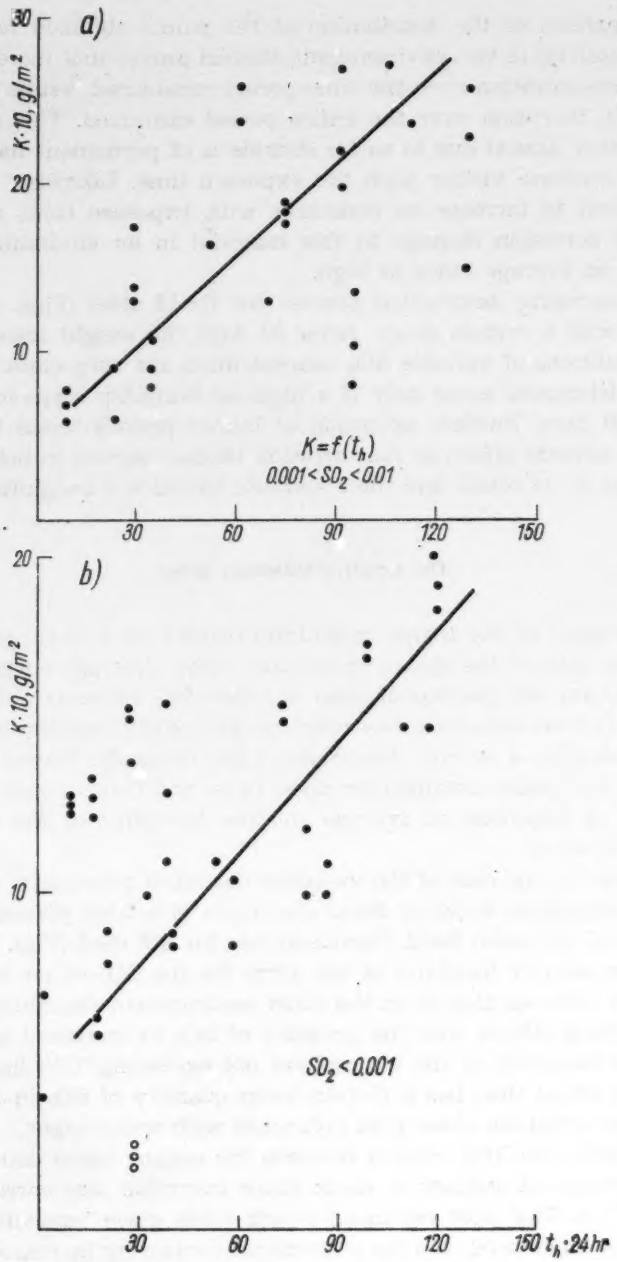

Fig. 4. Corrosion of OH13 steel as a function of the number of days with a relative humidity above 80%. Denotations as in Fig. 1.

Comparison of the distribution of the points obtained for St3 steel (Figs. 3*a* and 3*b*) in two environments studied proves that increased sulfur dioxide concentration over the time period considered results in fourfold increase in corrosion over the entire period examined. This means that the corrosion hazard due to sulfur dioxide is of permanent nature and it does not decrease visibly with the exposure time. Likewise, H6S2 steel fails to tend to increase its resistance with exposure time, so that the degree of corrosion damage to this material in an environment richer in SO_2 is on average twice as high.

The corrosive destruction process for OH13 steel (Figs. 4*a* and 4*b*) proceeds with a certain delay. After 30 days the weight losses recorded under conditions of variable SO_2 concentration are very close. More substantial differences occur only if a high air humidity stays for the subsequent 30 days. Further extension of humid periods seems to have no longer an adverse effect, as the corrosion losses observed in both environments tend to be equal, and their absolute values are insignificant.

The Relative Humidity Effect

On account of the corrosive buildup formed on a metal surface, the destruction rate of the metal varies with time. Average corrosion rates determined for any periods of time are therefore incomparable. The behavior of various materials, however, can be analyzed on the basis of the values related to a strictly determined time intervals. Shown in Figs. 5 and 6 are the results obtained for one-, two-, and three-month exposures expressed as functions of average relative humidity of the air in the period considered.

Just like in the case of the variables discussed previously, the nature of the relationships between these quantities is related primarily to the properties of the metal itself. Corrosion rate for St3 steel (Figs. 5*a* and 5*b*) for a given relative humidity of the air is for the SO_2-richer atmosphere roughly 20 times as high as in the other environment examined. This indicates, among others, that the presence of SO_2 in increased amounts at an average humidity of the atmosphere not exceeding 75% has a higher destructive effect than has a 10-fold lower quantity of SO_2 in the atmosphere under condition close to its saturation with water vapor.

For H6S2 steel the relation between the weight losses determined at both experimental stations is much more favorable and corresponds to a ratio of 1:2. The most enhanced attack takes place immediately after the metal is introduced into the atmosphere containing increased amounts of SO_2.

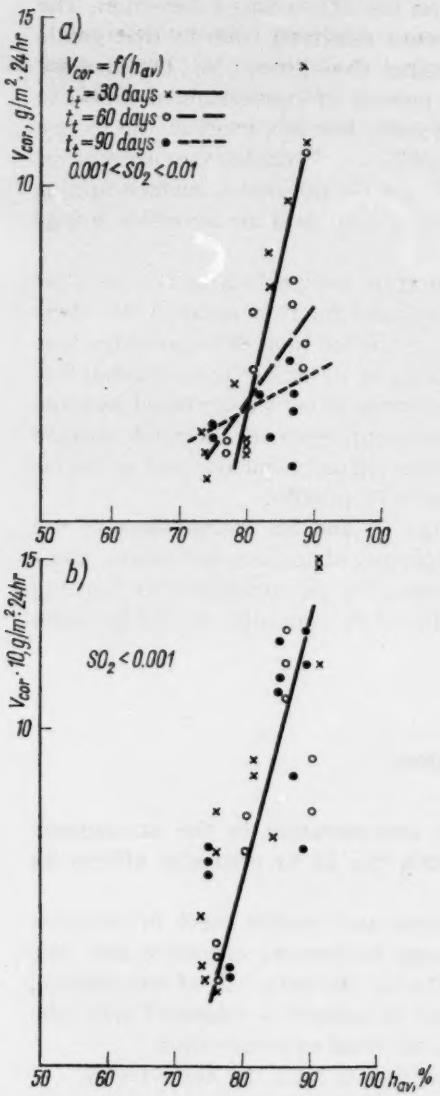

Fig. 5. Corrosion rate of St3 steel as a function of average relative air humidity: h_{av} — average humidity; other denotations as in Fig. 1.

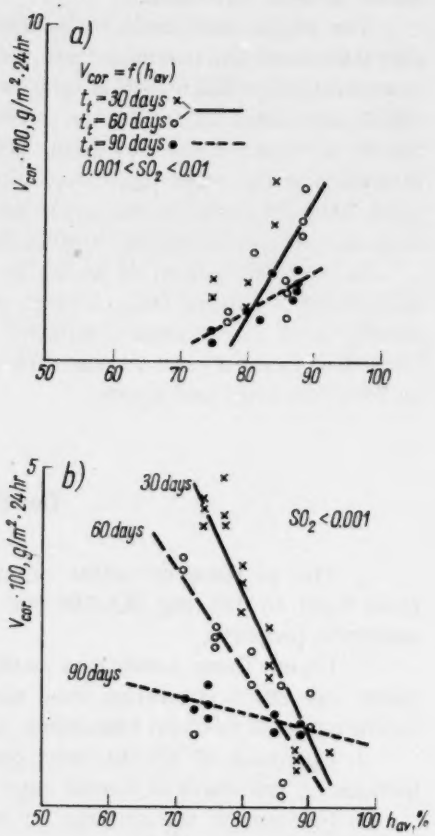

Fig. 6. Corrosion rate of OH13 steel as a function of average relative air humidity: h_{av} — average humidity; other denotations as in Fig. 1.

Figures 6*a* and 6*b* show, more clearly than for other variables discussed, the synergetic effect of humidity on the SO_2-induced corrosion. The behavior of OH13 steel in an environment relatively rich in that gas is roughly the same as for other low-resistance steel grades, i.e., the increase in average air humidity enhances the process of conversion of metal to ionic state. In the environment of a relatively low SO_2 content, the nature of the humidity relations changes principally. Probably on account of a partial decrease of adsorption of this gas on the metal surface and as a result of dilution of the electrolyte layer, increased air humidity brings about reduced corrosion.

The major conclusion to be drawn from comparison of the peculiar distribution of the corrosion rate points found for this metal in the environments under discussion is that even at not too high SO_2 concentrations OH13 steel loses its ability for self-healing of its oxide layer. Similar behavior is observed for H17 steel. The adverse effect of increased average humidity in the more aggressive environment, however, is much weaker here. After 90 days corrosion rate becomes virtually independent of variations in relative humidity ranging from ~70 to 90%.

In the distribution of points in Figs. 5*a* and 5*b*, independent of the differences resulting from diverse properties of individual metals, noteworthy is a fairly close similarity especially as concerns the limiting hazardous humidity. In all cases the value of this quantity should be taken as 75% humidity and above.

Conclusions

1. The increase of sulfur dioxide concentration in the atmosphere from 0.001 to 0.01 mg SO_3/100 cm² PbO_2 per 24 hr critically affects its corrosive property.

2. Under these conditions both structural carbon steel of common grade and OH13 chromium steel undergo accelerated corrosion over the entire range of medium humidities of the air characteristic of our climate.

3. Corrosion of all the steel grades examined is enhanced with the increase in the share of humid days in the total exposure time.

4. Increase in the average air humidity follows the same trend.

5. Influence of the atmosphere containing less than 0.001 mg SO_3/100 cm² PbO_2 per 24 hr reflects itself in a moderate corrosion of St3 and H6S2 steel.

6. With respect to the remaining materials examined the environment of that kind is not hazardous over the entire range of air humidity.

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Wojtacha, Z.

AIR POLLUTION CONTROL IN THE KATOWICE METALLURGICAL PLANT, A NEWLY BUILT POLISH METALLURGICAL INDUSTRY UNIT

(Ochrona powietrza nowoczesnego zakładu hutniczego Huty Katowice)

Air pollution control problems related to the construction of a modern integrated steelworks, the Katowice Metallurgical Plant, are covered here. Discussed are such subjects as localization of the plant, emission sources, as well as the measures to reduce the amounts of the emissions discharged. The influence of the emissions released on the environment surrounding the plant is analyzed.

A modern industrial plant today, that is, in the present period of a dynamic growth of industrialization and urbanization, should feature not only good technological indices and economical effects; it should not pose a serious threat to its surrounding environment and should provide adequate working conditions for man. The major issue in the design of the Katowice Metallurgical Plant under construction has been a modernity from the viewpoint of the technologies and equipment used as well as in the aspect of environment pollution control. For an integrated approach to this latter problem a number of scientific and specialist engineering companies in this country and abroad have been brought together for cooperation, such as the Polish Academy of Sciences, Institute of Geodesy and Cartography, Institute of Ferrous Metallurgy, Częstochowa and Silesian Technical Universities, "Gipromez" of Moscow, Lurgi Company from West Germany and some others. In the design stage among the major tasks considered were: choice of a suitable localization of the plant in relation to populated areas, air and water pollution control, noise reduction at least to the level as provided by the standing regulations, maximum humanization of workplaces, waste utilization and dust recontamination control measures, delineation and development of the protection zones around the plant, measures to ensure correct operation of the equipment

designed for environment pollution control. These tasks are to be achieved by organization of specialized services for that purpose. This article is concerned with the body of problems related to the atmospheric air pollution control.

Localization of the Katowice Metallurgical Plant

Localization of the plant was considered in terms of the whole country, the region, as well as the site itself. A total of eighteen localization variants had been contemplated. The criterion for localization on the nationwide scale was the minimum rail transportation. Three sites were considered in the aspect of ore supply, charge materials supply, and shipping of semifinished and finished goods to the users. According to this criterion the least rail transportation was involved for the siting in the Katowice Voivodship. The regional criteria were: environment protection, availability of space for building of the housing for the employees in an adequate environment, convenient transportation links, water supply, as well as the topographic conditions suitable for the construction of the plant. More than ten variants were taken into consideration on the regional scale. The best one was found in the eastern part, downwind of the highly congested Upper-Silesian Industrial Region. In the selection of the situation the variant at Ząbkowice-Łosień, which has finally been put into effect, was found most advantageous. The general plan of the plant provides that the departments of a least nuisance to the environment be located upwind on the direction of prevailing winds, whereas the more polluted departments should affect the areas included in the protection zone of the plant.

Description of the Katowice Metallurgical Plant Localization Area

The area on which the metallurgical plant is localized is situated on the NEE part of the Upper-Silesian Industrial Region border, about 20 km away from its center. In physiographic terms the plant is situated in the eastern part of a region known as Tarnogórski Flexure. Climatic conditions of that area are moderate, between the oceanic and continental ones. Surface winds exhibits deviations with respect to the general wind rose for the Upper Silesia and Zagłębie (the Coal Basin). According to the 1971 data the atmospheric pollution level (background) in the plant localization region was as follows:

— dust fall — 157 to 205 tons/km^2 per year,

— mean annual SO_2 concentration — 0.02 to 0.10 mg/m³,

— mean annual airborne dust concentration — 0.02 to 0.08 mg/m³,

— frequency of the exceeded instantaneous concentrations for dust (0.6 mg/m³) — 1 to 2.5%,

— frequency of the exceeded mean 24-hr concentrations for SO_2 (0.35 mg/m³) — 1 to 5%,

— frequency of the exceeded instantaneous concentrations for SO_2 (0.9 mg/m³) — 0.5 to 1%,

— frequency of the exceeded mean 24-hr SO_2 concentrations (0.35 mg/m³) — 1 to 5%.

The condition of pollution in that area is due to the following industries:

dust

— power industry ~28.5%,

— utilization and house furnace ~20%,

— chemical industry ~12.2%,

— ferrous metallurgy ~11.5%,

sulfur dioxide

— power industry ~49%,

— ferrous metallurgy ~12%,

— chemical industry ~9%,

— nonferrous metallurgy ~6.5%.

Examples of the analysis of the background in the area of plant localization are given in Figs. 1 and 2. The data are taken from the study made by Department of Environment Protection of Industrial Region, Polish Academy of Sciences.

Emission Sources and the Measures to Reduce Emission Rates

The Katowice Metallurgical Plant is a typical high-volume modern metallurgical plant of a designed capacity about 4.5 million tons of crude steel per year in the first development stage, to be subsequently expanded to a capacity of 9 million tons of crude steel per year. This future expansion has been considered in the plan by suitable acreage of the land and the layout of individual units. The following production units will be encompassed by the plant:

— charge preparation plant inclusive of a sintering plant equipped with three sinter belts,

— blast-furnace plant, incorporating two 3200-m³ furnaces,

— oxygen converter shop, with two 350-ton converters with a capacity of 4.5 million tons,

— semifinishing mills for large- and medium-size steel goods.

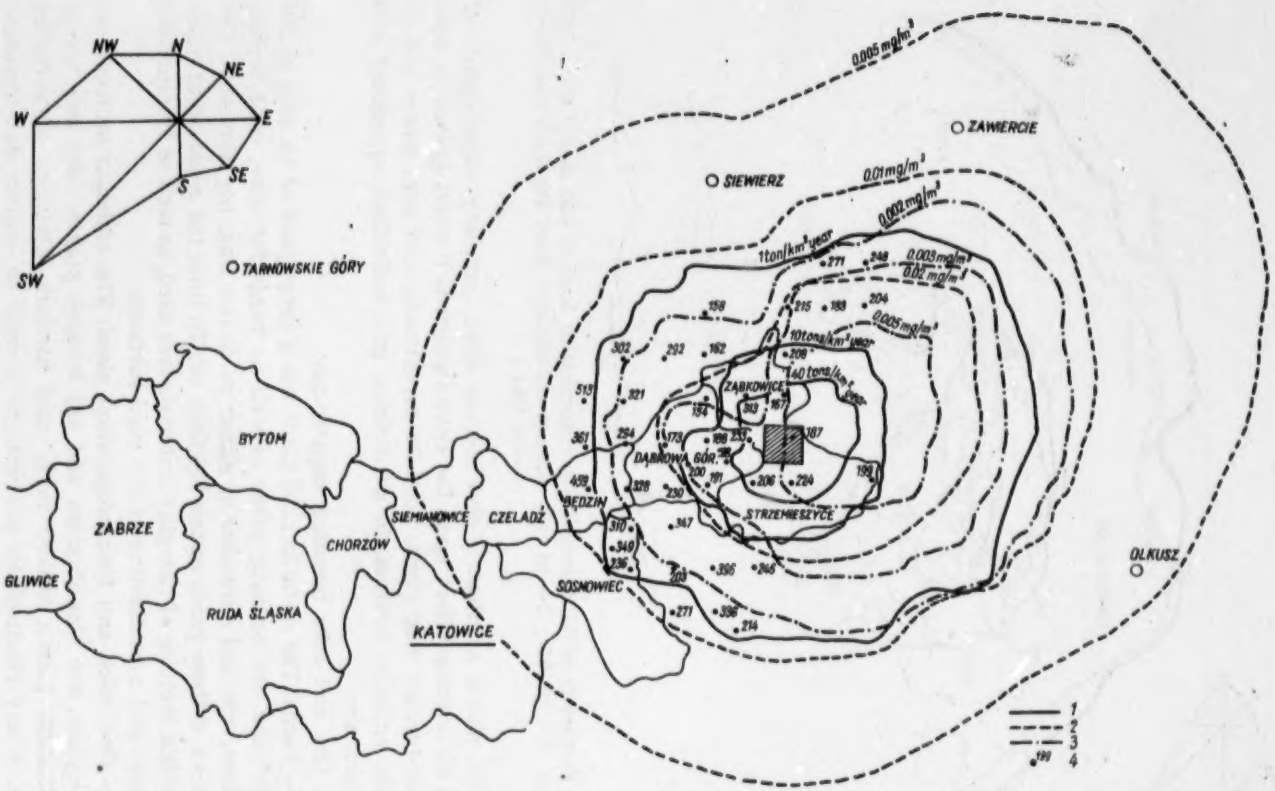

Fig. 1. The background and the forecast for mean annual concentrations of emissions from the Katowice Metallurgical Plant: *1* — dust fall; *2* — dust concentration; *3* — SO_2 concentration; *4* — dust fall background, ton/km² year.

Fig. 2. Frequency of the exceeded SO_2 concentration level of 0.35 mg/m³ and a 1978 forecast: *1* — in 1971; *2* — in 1978 without contribution from the Katowice Plant; *3* — in 1978.

The plants mentioned also include some auxiliary departments of which an adverse effect upon the environment will exert primarily such as blast-furnace slag plant, limekiln department, and heat power plants.

The emission sources, in subdivision into individual equipment and processes, are:

1. Ore and coke blending department:

— Yards. The metallurgical plant has a surge yard of an area of 104 thou m² and ore bedding yards as well as yards for coke, coke breeze, limestone, ore, and a number of minor yards (for slag, pig iron, etc.). The total area of these yards equals 174 thou m². To limit the emission as much as possible, wetting of charging materials was used, as well as tranquilized transport and consolidating of the yard surfaces.

— Ore, coke, and flux preparation plant. The emission sources here are: tipplers, ore classification and ore breaker plants, coke and breeze classification plants, breeze mills, and batching divisions of sintering plants. A dry electrostatic precipitator is used to control dust emission

from tipplers, as well as for ore and coke classification plants, breeze mill, and ore and flux breaker plants. In the preliminary blending department for each blender an individual dust control unit has been provided, which is a wet collection device of a foam scrubber type.

— Sintering plant. The major emission source here are sintering belts, for which dry electrostatic precipitators are used. For dust control over auxiliary units such as unloading points of sintering belts, sinter crushers and classification departments, and distribution point, also dry electrostatic precipitators are provided. Mechanical collection equipment was applied for the control of coarser dust exhausted from other emission sources as sinter coller and distribution point (cyclones, multicyclones). The return undersize sinter belt has been provided with a Venturi type wet collection system.

2. Blast furnace plant. Here the principal emission sources are the batching plant, blast furnaces, and ladle bay. For the dust control in the batchers two dry electrostatic precipitators were used, while in the ladle bay fabric filters were employed. The particulate and gaseous emission source for blast furnaces is crude blast-furnace gas that escapes into the atmosphere through the leaks. A minimum losses of blast furnace gas through leaking has been achieved owing to the use of the most advanced devices which are Wurth's type bell-less seals. It will be mentioned that a considerable emission of sulfur compounds in the form of SO_2 and H_2S will be involved in that department during direct slag granulation.

3. Oxygen converter plant. As a result of intense processes used there with help of oxygen, the plant is a serious emission source especially of solid particulates of submicron size. This is particularly true of the converter smelting process. For exhausting and treatment of the gases produced in these plants an OG type system was provided, which is based on an import purchase without gas afterburning. This installation is the first of this kind in Europe. Of the total quantity of the gas exhausted 70% is to be used for power industry purposes. The remainder, i.e., 30%, in view of too low a CO content (<6%), will be burned up in a flare. Dust concentration in the exhausts discharged will not exceed 100 mg/m³. Other emission sources present in the plant, such as bulk materials line (lime classification, discharging points, and batchers) as well as reladling and deslagging stands, also casting and tapping stands are provided with fabric filters.

4. Limekiln department. The basic dust emission sources are lime bunkers and kilns. To reduce dust emission from these emitters, fabric filters were used in either case.

5. Rolling mills do not represent a serious dust pollution source, as the emission there merely appears in scarfing machines. A wet electro-

static precipitator was used to control the gases exhausted. It will be emphasized that this department is a serious emitter of CO and NO_x.

6. Salvage department. This department consists of the following units: slag processing plant, used fireclay brick and tar-dolomite brick sorting departments, package sorting plant, sludge preparation plant, and scale sorting and breaking plant. The air pollution largely stems from the slag processing plant. In the same department also primary waste from dust collection from waste gases is produced. For emission control in slag processing plant, dry collection equipment (battery cyclones) was used.

The total emission volume at an annual output of 4.5 million tons of steel will amount to about 20 thou tons of dust, 40 thou tons of SO_2, 3700 tons of H_2S, 125 thou tons of CO, 12.5 thou tons of NO_2, 220 tons of HF and 200 tons of HCN.

A total of 20.5 million m^3/hr exhausts and waste gases will be treated in the metallurgical plant. The overall dust entrained along with waste and exhaust gases will be over 796 thou tons per year, which corresponds to 177 kg/ton of crude steel. Of this quantity about 2.7% dust will be emitted, which confirms the opinion that a very high integrated collection efficiency has been achieved, above 97%. This condition will be accomplished by installation of 57 dust collection equipment, in that number 24 dry electrostatic precipitators, 15 bag houses, 7 mechanical devices (cyclones, multicyclones), 10 wet collection stations (Venturi types) and one wet electrostatic precipitator. The quantity of the gases treated in that equipment will be over 17 million m^3/hr.

The sulfur input to the plant is estimated at over 41 thou tons/year. Of that amount over 23 thou tons/year will be discharged into the atmosphere as SO_2 and H_2S. This corresponds to 57% sulfur delivered along with feedstock and fuels to the plant. The SO_2 and H_2S emission is limited merely to a few sources, namely, to sinter machines, slag granulation machines and heat plant. Sulfur compounds are present in minor quantities also in converter gas.

No SO_2 treatment facilities were provided in the plan of the metallurgical plant construction at the present stage of its development, as no economically sound large-scale methods for desulfurization of the low-SO_2 exhausts are available today. Space has, however, been reserved in the master plan of the plant for installation of that kind to be set up in the future. Now merely high stacks were designed, whose height ensures the concentration level of these pollutants to stay within the limits specified by regulations.

The major share in the particulate and gaseous pollution with dusts, sulfur compounds and other compounds, as NO_x, CO, HF, or HCN, belongs

to charge processing departments, i.e., charge preparations plant, blast furnace plant, moreover to heat plant. To give an example, the share of charge preparation and blast furnace plants is, respectively, for dust — 82%, sulfur compounds — 81%, CO — 81%, NO_x — 43%, HF and HCN — 100%.

Effect of the Emissions Discharged by the Plant upon the Environment

Parallel to the designing of technological preventive means to abate pollution from the Katowice Metallurgical Plant, inventory work was conducted in the environment of the plant localization region, as well as research work to determine the range of dispersal of these pollutants and to forecast their adverse effect upon the ecology of the region. The whole work was accomplished by the Polish Academy of Sciences Institute of Environmental Engineering in Zabrze in cooperation with a number of specialist research centers. Synoptic maps were plotted for the region on the basis of such forecasts, examples of which are given in Figs. 1 and 2.

It follows from the forecasts made that the activity of the Katowice Plant will give rise to increased pollution as follows:

— maximum rise in dust fall — up to 40 tons/km² year,

— increase in the mean annual concentration of airborne dusts — to 0.002 mg/m³,

— increase in mean annual SO_2 concentration — 0.005 mg/m³.

Maximum range of the perceptible influence of the Katowice Plant will be:

— for the dust fall in a quantity of 1 ton/km² year — to 14 km,

— for mean annual dust concentration at a level of 0.005 mg/m³ — up to 30 km,

— for mean annual SO_2 concentration at a level of 0.002 mg/m³ — up to 16 km.

Maximum broadening of the exceeded concentration frequency zones:

— dust concentration 0.2 mg/m³ — to 10 km,

— dust concentration 0.6 mg/m³ — to 12 km,

— SO_2 concentration 0.35 mg/m³ — to 5 km,

— SO_2 concentration 0.90 mg/m³ — to 4 km.

The largest range of the influence occurs on the northeast direction from the plant. The research study mentioned included also problems of the influence of discharged emissions upon forests, agricultural land, orchards and gardens, soils and animals and also on the health conditions of population, aquatic environment and corrosion of metal structures.

Based on the research studies mentioned it was estimated that the atmospheric emission levels due to the activity of the Katowice Plant will cause damage in the range of its influence and will entail costs, among others:

— in forestry, about 6 million zlotys,

— in agriculture, orchards and gardens, about 10 million zlotys,

— due to corrosion and decaying of the buildings, about 14 million zlotys,

— caused by dumping grounds, about 5 million zlotys,

— in the animal farming, about 60 million zlotys.

The costs of countermeasures against harmful effects of the metallurgical plant emission is estimated at ~170 million zlotys per year. This amount includes the amounts required for reconstruction of agriculture and forestry, animal farming, dump reclamation. The costs will decrease with the progress in the work related to reconstruction of the whole of animal farming, agriculture and forestry.

However, for a correct and exhaustive appraisal in this field, many year comparative studies will be carried out in the entire zone of influence of the plant.

Conclusions

The Katowice Metallurgical Plant has been localized in the region of a fairly high emission background level. The environment pollution control problems and the questions of minimalization of the deleterious influence of the plant upon the environment have become one of the key tasks in the design stage. To abate emission rate a number of measures have been taken of both the active kind, i.e., in the field of the assumption of engineering variants and the variants of the equipment design, and of passive kind, by the use of high-efficiency dust collection equipment of advanced design. An example of the latter may be the use of electrostatic precipitators manufactured under the license purchased from Lurgi Company. Mention will be made of such adequate metallurgical processes and equipment design as:

— use of low-sulfur fuels and materials as wide as possible, depending upon the national availability of such materials,

— decreased use of external fuels by the utilization of secondary power resources, as waste heat and secondary fuels (converter gas),

— construction of high stacks to ensure adequate dispersal of emissions discharged, particularly gaseous emissions like SO_2 (a 250-m stack has been built on the sintering plant),

— water spraying of ore and remaining materials in the yards particularly during bedding operations,

— production of high-basicity sinter,

— the use of a carefully prepared (screened) charge to blast furnaces and feeding of the charge by means of tranquilized conveyor-belt transport,

— application of the nitrogen-filled bell-less Wurth's type seals in blast furnaces; owing to this, losses of crude blast-furnace gas will be reduced to ~2% against the losses for the currently used seals which amount to 6–10%,

— installation of an exhaust system with venting of the fumes produced during slag granulation process through a stack 100 m high,

— pneumatic transport for loose dusty materials,

— extensive measures for utilization of useful waste and solidification of useless waste designed for dumping,

— application of tranquilized transport and delivery of loose materials,

— intensification of the blast-furnace process by enriched oxygen blast to over 30% and increased blast pressure in the throat, which substantially reduce dust entrainment from the furnace.

It was generally assumed for the whole metallurgical plant that dust concentration in the gases released is not to exceed 100 mg/m³.

All the solutions adopted, along with the integrated approach to the air pollution control, give a guarantee that this most modern metallurgical plant meets the requirements of its minimum influence upon the environment, and place this plant among the leading ones in the world as concerns pollution control. This point is supported by the assumed indices of emission rate per one ton of crude steel produced. Thus, for the production of 4.5 million tons/year the expected dust and SO_2 emissions are, respectively, 4.5 and 8.8 kg/ton. For comparison these indices are: in the "Lenin" Metallurgical Plant with a steel output of 6.3 million tons, 16.1 kg dust/ton crude steel and 11.8 kg SO_2/ton crude steel, whereas for old metallurgical industry for a steel output of 2.8 million tons the respective figures are 20.2 and 12.8 kg/ton crude steel for dust and SO_2, respectively.

Irrespective of the engineering projects, two protective zones will be formed to encircle the plant, viz.:

— Strict protective zone of an area of ~8 km². The limit of that zone will run at the following distances from the plant fence: 500 m south, 1000 m west and 2500 m eastwards.

— Extended protective zone of an area of ~70 km². Its limit will run at the following distances from the plant fence: 2.8 km south, 3.5 km

west, 5.2 km north, and 5.4 km east. This is an intermediate zone under special supervision over the atmospheric air quality.

In the extended protective zone four automatic monitoring stations will be set up. The stations should be connected to the currently developed air pollution control monitoring and emergency alerting network of the Katowice Voivodship.

For a correct solution of the whole body of problems related to operation of the equipment and to supervise the observance of the pertinent regulations by the plant, formation of special services has been provided, viz.:

— departmental services,

— general plant service.

The tasks of the special departmental services resolve themselves into direct operation, maintenance, and minor repairs of all the pollution control devices and installations. The major duty of the general plant service is engineering management, coordination of supervision and control of the whole of the activities of the plant with respect to micro- and macro-environment protecting.

In conclusion it will be emphasized that the main objective of the Katowice Metallurgical Plant project is modernization of old-fashioned metallurgical industry in the Upper-Silesian Region, among other things, by substitution of large modern units for low-efficiency iron-manufacturing departments. This will result in a drastic reduction of emission from the existing metallurgical units in the Upper-Silesian Industrial Region. Reduction of dust emission by metallurgical industry in that region is roughly estimated at ~50 thou tons/year by 1990. The problems of air pollution control in the Katowice Metallurgical Plant have been worked out entirely by the "Biprohut" Designing Office. The equipment was supplied by national industry.

LEGAL ASPECTS AND ORGANIZATION

Activity of the Norwegian Air Research Institute

The Norwegian Air Research Institute (Norsk Institutt for Luftforskning) at Kjeller near Oslo is the main executor and coordinator of research in the field of air pollution control in Norway. Created in 1969 the Institute incorporates four departments: chemistry of the atmosphere, measuring instruments, local sources pollution level analysis, and remote emission dispersal analysis.

In major urban and industrial regions of Norway the pollution measurements are carried out by local agencies which forward results of their measurements to the Kjeller Institute. In that Institute also more complicated analyses are made. Results of the studies form a basis for limitation of emission rates. Aside from pollution measurements the Institute performs additional determinations of meteorological elements.

Remote dispersal and transport of emissions in Norway is a subject of particularly intense studies. The Norwegian investigations indicate that the quantity of emissions that get into the soil and waters in Norway exceeds the national emission rate. Interesting data on this subject are reported by H. Dovland, E. Joranger, and A. Semb in their paper: Effect of Acidic Precipitation upon the Sylvatic and Aquatic Ecosystems, chapter: Fallout of Pollutants in Soils and Waters (original title: Impact of Acid Precipitation on Forest and Freshwater Ecosystems in Norway, Research Report, Fagrapport FR 6/76, Oslo, Ås, 1976). The incentive for the research was the finding of a gradual increase of the acidity of precipitation in Norway in 1955 through 1970, and enlarged range of the influence of acid precipitation. The work is based on results of studies conducted in the period from July 1972 till June 1975 and concludes the first stage of research project scheduled until 1979. Pollution concentration in precipitation was measured by a networks shown in Fig. 1. Precipitation samples from all Norway are mailed to the Kjeller Institute. The measuring points are localized away from local emission sources. At seven stations also air pollution was measured.

In precipitation examined prevail SO_4^{2-} ions, followed by H^+, NH_4^+, and NO_3^-. Mean annual SO_4^{2-} concentrations in precipitation range from 4.5 mg/l in southern Norway to 1.0 mg/l in the middle part of that country. The values given refer to the sulfur discharged from antropogenic sources. At the stations situated on the coast the part of the sulfates of natural origin amounts to about 50%, dropping to about 10% inland. The sulfates fallen out with precipitation and found in soil attain the highest value on the southern coast (4.1 g/m² is the annual mean there). Generally the sulfate fallout is high in southern and southwestern parts of the country, which is additionally due to high precipitation there for orographic reasons. The studies show that the sulfate fallout in Norway exceeds two to three times the emission rate of this country, which is low in view of hydroelectric power produced. Enhanced sulfate fallout is periodic. Specifically, in the south coast of Norway about 25% of total sulfates that enter the soil and freshwaters with precipitation over three years occurs during a 15-day period. On the basis of the windfield at an altitude of 850 m, trajectories are determined for the air masses that carry along emissions from remote source situated in the industrial regions of Europe. For the same purpose measurements are made of the vertical gradient of SO_2 and sulfate aerosol concentrations, and meteorological elements are determined by means of planes (Y. Gotaas). Emission transport at remote distances is also the subject of investigations by B. Ottar.

Fig. 1. The monitoring network for determination of contaminants in precipitation: ● — 24-hr sampling; ■ — weekly sampling; ▼ — monthly sampling.

Model calculations by Eliassen and Saltbones show that dry fallout of sulfates in Norway represents 30% of total sulfates precipitated that enter soil and water.

Spatial distribution of sulfate fallout is in general agreement with the distribution observed for nitrates, hydrogen ions, ammonium ions, and heavy metals or organic compounds which are polycyclic aromatic hydrocarbons (PAH) and polyhalobiphenyls (PHB).

The rise in sulfate and nitrate concentration in precipitation in Norway is associated with decreased pH of precipitation. In the south of Norway about 70% of precipitation has a pH value below 4.5, although values below 3.5 are also observed. In the central Norway the frequency of precipitation with pH below 4.5 is 20%. Increased acidity of precipitation entails unfavorable changes in sylvatic and aquatic ecosystems in that country, as demonstrated by the studies of the Norwegian Water Research Institute and the Norwegian Forest Research Institute (in the paper cited above).

The Norwegian Air Research Institute issued a map for SO_2 emission in a grid 127 km long. Within the framework of further research the Institute embarked upon unification of the measuring methods for atmospheric emissions on an international scale (European Monitoring Programme, Manual for Sampling and Chemical Analysis Procedures, July 1976). The map was based upon official data supplied by individual countries (including Poland), members of the European Economic Committee by the UNO. The manual mentioned provides methods for the determination of the following pollutants: sulfur dioxide, sulfate and strong acid aerosols in the air, as well as the sulfates, strong acids, nitrates and ammonium ions in precipitation. Measurements of mean 24-hr concentrations are recommended. The analytical work in the Institute is headed by K. Thrane and J. Hansen.

Sulfur dioxide is determined by the thoron method as sulfates produced by absorption in H_2O_2 solution of a pH = 4.5 preceded by filtration of the air under analysis through a Whatman 40 paper filter. At low SO_2 concentration (below 10 $\mu g/m^3$) absorption of SO_2 on a KOH-impregnated paper filter is recommended.

For the determination of sulfate aerosol the X-ray fluorescence analysis technique is suggested as a very sensitive one. Sulfates in precipitation are determined by the thoron method. This method is also good for analysis of sulfate aerosol arrested on the filter upon dissolving of sulfates in water.

Strong acids in the form of aerosols and in precipitation are determined by coulometric titration.

Ammonia is determined by the indophenol method. For the analysis of nitrates a procedure is advanced which is based on the Griess reaction following the reduction of nitrates to nitrites with cadmium analgam.

Prepared by S. Kasina

From the Jurisdiction of the Supreme Court

The problems of protection of the environment against deleterious effects of industrial emission are also the subject of legal procedures. Reported below are a few judgments of the Supreme Court in this field.

In a manufacturing plant discharging noxious emission used all the available means to control these emissions, and an owner of a land situated within the range of the pollutional influence of the plant, despite filed management procedures on his part to neutralize the soil contaminants, suffered damage in crops, then the plant's liability for damage essentially includes damages in their full amount. The grounds for restrictions of such a liability occur under conditions if the activity of the manufacturing plant or of the land proprietor undertaken to neutralize noxious emissions involves some inappropriateness. The inappropriateness in this activity on part of the sufferer entails limitation of the amount of the damages he is entitled to, in force of art. 362 of the Civil Code.

With respect to the manufacturing plant a decrease in the amount of damages granted to the sufferer may be acknowledged on the basis of public interest, if the productive activity of such plant is desirable from the public interests' viewpoint.

Judgment of March 11, 1974, court records III CRN 9/74 published in Orzecznictwo Sądu Najwyższego Izby Cywilnej oraz Izby Pracy i Ubezpieczeń Społecznych (The Supreme Court Jurisdiction, Civil Section and Labor and Social Security Sections), No. 11/74, sec. 202.

In conformity with art. 444 par. 1 Civil Code, in case of inflicted health detriment, the damages include all the costs entailed. If the sufferer's health was impaired due to deleterious air contaminants discharged by an industrial plant (art. 435 CC) and its further residence in the dwelling he occupies, and which is situated within the range of influence of noxious emissions, offers a threat of development of the disease, the damages include also the expenses necessary to obtain another apartment which would correspond to the previous living standards of the sufferer and to the regulations concerning living space per person.

Judgment of October 13, 1976 court rec. IV CR 487/76, unpublished.

From the evidence collected in a case it seems that the plaintiffs had been aware of the harmful effect of industrial dust from the "Bonarka" Plant in Cracow as long ago as 1961. The plaintiffs have already received damages in excess of one million zlotys in previous trials. Meanwhile, the plaintiffs, despite their arguing that their glasshouses were situated in the center of the harmful influence of the "Bonarka" Plant, they kept on expanding their glasshouse business over the years 1961 to 1968. This behavior, when a farmer, being fully aware of a possible damage, keeps, on

developing his farm for which there are actually no satisfactory conditions, cannot be indifferent by force of art. 362 of Civil Code.

Judgment of August 26, 1976, court red. II CR 206/76, unpublished.

The cause and effect relation between a definite illness of a sufferer and activity of an industrial plant that emits deleterious substances should be deemed demonstrated if only it was established that the sufferer was exposed to the influence of deleterious pollutants discharged by the defendant plant, whose natural consequence may be a disease of the sufferer.

Judgment of October 6, 1976, court rec. IV CR 380/76, unpublished.

Prepared by K. Gustyn

New Gas Filters

The Ultrafilter GmbH Company from Federal Republic of Germany starts marketing filters of new design for compressors, motors, and pumps, which feature a high performance conforming to international standards.

The one-year guarantee offered by the company for these filters covers the types designed for sterile filtration, for complete removal of oil, water, and dust from air and gases, for tight filtration of liquid and vapor, and for removal of particulate matter and odors. Each of the filter types was designed to provide optimum efficiency as concerns capacity, operation and pressure loss, characteristic of each filter size made (Fig. 1 and Table 1).

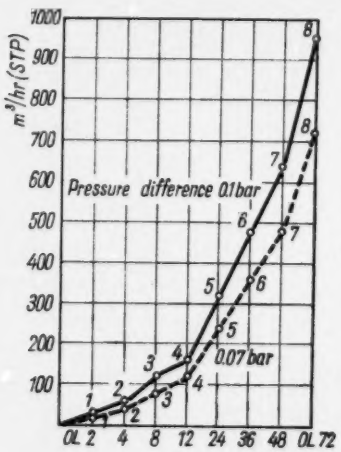

Fig. 1. Capacity vs. filter size (for eight size types).

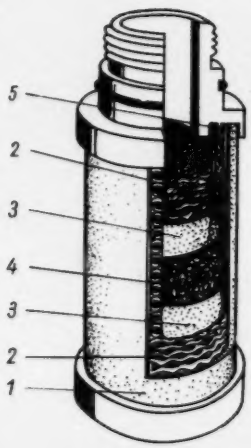

Fig. 2. Filter insert: *1* — foam shield; *2* — stainless-steel supporting sleeves; *3* — first stage (preliminary filter beds); *4* — second stage (a spatial nonwoven); *5* — sealing.

Of other advantages are: two-stage filter insert of a new design, interchangeability of individual parts and housing, as well as lower price of the unit.

By way of example for following filter capacities are available: for the removal of oil and water (down to a level of 0.01 ppm) the filters are made for a capacity of up to 28,000 m³/hr (STP), operating with an overpressure of 7 bars. Filters operated at an overpressure of 10, 16, or 25 bars,

Table 1

Specifications for Eight Type Sizes of Filters Designed for Compressors

Points of the plot in Fig. 1	Compressor power hp	Optimum filter size corresponding to a definite compressor power				
		filter type	joint diameter in.	filter area cm²	minimum flow rate at a pressure difference 0.07 bar m³/hr (STP)	minimum flow rate at a pressure difference 0.1 bar m³/hr (STP)
1	4	OL 2	3/8	23.93	20	30
2	7.5	OL 4	1/2	47.85	40	60
3	15	OL 8	3/4	79.76	80	120
4	20	OL 12	1	119.63	120	160
5	40	OL 24	11/4	239.27	240	320
6	60	OL 36	11/2	358.90	360	480
7	80	OL 48	2	478.54	480	640
8	120	OL 72	2	717.80	720	960

as well as units of capacity up to 30,000 m³/hr (STP) operating under 7-bar overpressure (for sterile filtration) can also be ordered. For liquid filtration the filters are made of a capacity ranging up to 216,000 l/hr. In all cases the pressure loss across the filter does not exceed 0.07 bar. Filters for higher flow rates and higher overpressures are also available.

As a result of extensive research effort, three completely new major filter components have been developed, viz.: filter insert, filter medium, and housing. The newly designed two-stage filter insert consists of the inner part, which is a microfibrous nonwoven shielded on both ends by preliminary filter layers which arrest larger particles and ensure mechanical strength (Fig. 2). Both filter media used are chemically and biologically inert, and contain no substance that might contaminate the gas stream flowing, thus they meet the requirements of the American FDA.

The absence of binding material, coupled with a small diameter of the fibers, results in that the nonwoven medium contains 80% free space. A photograph of the nonwoven taken at a 2000-fold magnification is shown in Fig. 3. Owing to this a considerable absorbing ability of contaminants has been accomplished, along with increased collecting efficiency and re-

Fig. 3. A photograph of the nonwoven in a 2000 × magnification.

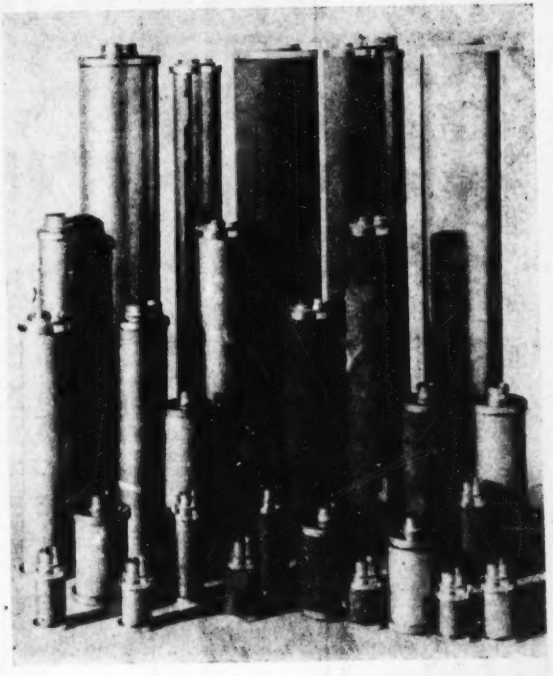

Fig. 4. Filter inserts.

duced pressure loss. The service life of the filter could be extended from one to three years (from 6000 to 10,000 hr) on account of the new filter insert design and increased filtering surface area by 28%. The filter can tolerate overloading up to 200% of rated capacity and increased temperatures to 200°C. The filter stack is supported on two stainless-steel sleeves

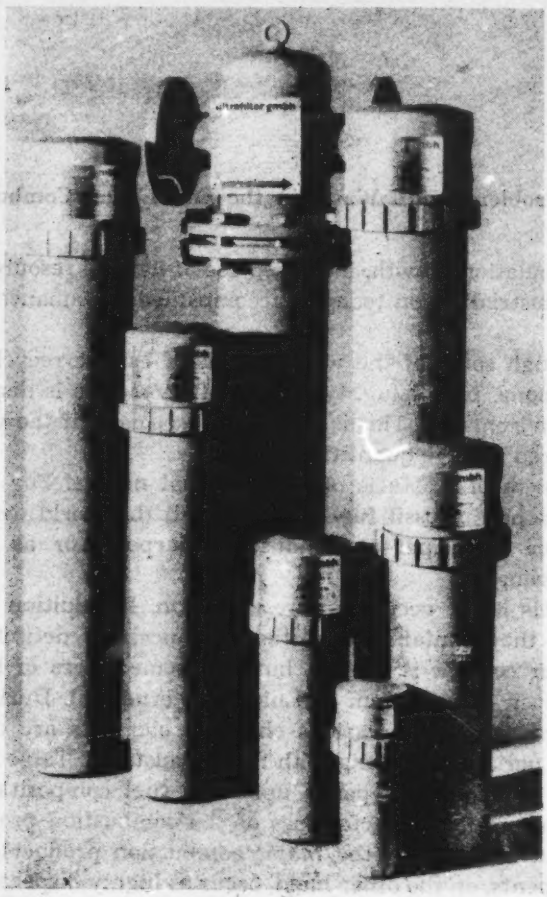

Fig. 5. Filters of various sizes.

joined to stainless-steel lids (Figs. 2 and 4). To eliminate aerosols, a plastic foam shielding was provided that arrests oil droplets particularly efficiently.

The housings (Fig. 5) are made of stainless steel, aluminum, or carbon steel in a streamline shape. The stainless-steel or aluminum housings are

equipped with a threaded clamp of special design that accommodates a sonic alarm device in case the seal starts leaking.

The carbon-steel housings are joined by flange, and their inside walls are coated with polyester resins. For all the currently manufactured housings the manufacturer gives a five-year guarantee for workmanship and material.

K. J.

The Problems with Waste in the Fossil Fuel Combustion

Rapid population growth, increased use of natural resources and ever-increasing industrialization today is accompanied by enhanced production of waste.

Even though some of the waste produced can be recycled by direct way or after some processing, typically, however, this is disposed of into the natural environment. This is irrational, especially if the waste is toxic or when dumped in huge quantities.

The problem of waste is of international nature. For instance, the major waste sources, fossil fuels, are used all the world over for power generation, for municipal and industrial purposes or as material for further processing.

Fossil fuels never occur in pure condition. In addition to carbon or hydrocarbons they contain some other chemicals in definite quantities. A 2–3% sulfur content is typical, but also some traces of heavy metals are present, such as vanadium and nickel in crude oil. During fuel combustion the compounds of various chemical elements are discharged as gases or solid particulates along with the exhausts (cf. Table 1). The share of individual compounds depends upon the fuel composition and upon physical and chemical characteristics of the combustion process.

As seen from Table 1, the major combustion products are gaseous. Minor components, on the other hand, occur as highly disperse suspensions and aerosols. Hence, the simplest, the least expensive and actually the most popular way of disposing of this waste is its venting to the atmosphere. No one has any doubts, however, that this procedure is unreasonable.

In this connection, people are concerned now with the influence of a variety of exhaust components upon the natural environment. Both water vapor and carbon dioxide are natural components of the air. Since about 100 km³ water escapes into the atmosphere over 24 hr in the natural cycle,

it can be soundly admitted that water vapor emission from combustion process is negligible. Much more substantial is the effect of the carbon dioxide emission.

Prior to the advent of our industrial era, CO_2 concentration in the atmospheric air stayed at a safe level of 0.3% by vol. Recent studies showed, however, a constant growth in CO_2 concentration in the atmosphere. Essentially this growth is parallel to the fossil fuel consumption (Fig. 1).

As shown in Fig. 1, during the past 100 years the quantity of oil used for production has been rising exponentially. It was estimated that the to-

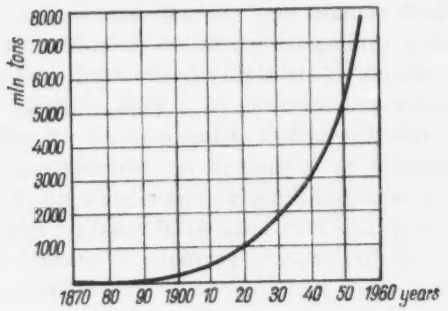

Fig. 1. World's production of the hydrocarbon fossil fuels by decades in the period 1870-1960.

Table 1

Waste in the Fossil Fuel Exhausts

Gaseous components	major components: water (H_2O) carbon dioxide (CO_2) minor components: sulfur dioxide (SO_2) (from zero to 0.3% by vol.) sulfur trioxide (SO_3) oxide of nitrogen (NO_x) carbon monoxide (CO)
Trace liquid components	hydrocarbons (aliphatic, polycyclic, and aromatic)
Trace solid components	carbon (C) vanadium compounds (V) } especially in oil nickel compounds (Ni) } silica (SiO_2) alkali metals heavy metals

tal quantity of carbon dioxide discharged into the atmosphere during combustion of this fuel is 500 billion tons.

The far-reaching consequences of this fact may prove serious, as carbon dioxide absorbs infrared radiation. Since solar energy originally irradiated in the infrared region will be stopped to a greater and greater extent, the earth's thermal balance will vary, as the infrared energy will be absorbed by increasing quantity of carbon dioxide in the atmosphere, just like it is the case of glasshouses, where the glass windows absorb infrared radiation emitted by soil.

Currently, however, of urgent interest is sulfur dioxide emission in the exhausts. Sulfur dioxide, aside from its irritating activity toward the lungs of people which remain near its emission source, in the atmosphere this substance slowly undergoes oxidation to sulfur trioxide. Sulfur trioxide, i.e., sulfuric anhydride, is highly hygroscopic and forms with atmospheric moisture mists and aerosols of a high sulfuric acid content. Not infrequently these aerosols, before being washed out with rain, are transported at long distances by motion of the atmospheric air. Sulfuric acid that falls on earth attacks buildings and steel structures. It may also affect the pH of soil as a result of the removal of alkaline component and acidification of waters. All freshwaters increase in acidity to the extent that the natural biological cycle is disturbed. In some freshwaters like, for instance, in the lakes and rivers of southern Norway, the lowered pH caused a complete extermination of fish there. It is believed that it is sulfuric acid contained in precipitation waters that is to blame. Sulfur dioxide is also the reason for increased concentration of the toxic triatomic oxygen molecule, ozone.

Atmospheric air and winds do not observe the borders. Hence, the problems caused by sulfur dioxide emission during fossil fuel combustion are of international concern. In accordance with belief a conference was held in Norway in 1976 with participation of representatives from over twenty countries, who convened to deliberate on the consequences of this emission and its possible abatement.

One of the most promising methods is the scrubbing of exhausts with water in which SO_2 dissolves. The absorption liquor is subsequently oxidized with atmospheric oxygen and the sulfuric acid produced is made neutral with alkalis.

The most convenient for this purpose is seawater which contains sufficient quantities of alkalis that originate from the carbonates and borates present there (Table 2). The liquid effluents produced can be fed in a controlled manner to sea, where their further neutralization would take place. Of utmost significance is a proper selection of the area of effluent discharge and the way it is done, as the waters receiving the effluents should

contain dissolved oxygen in sufficient amount to oxidize the remaining SO_2 in the spent scrubbing liquor; it should also contain sufficient alkalis to neutralize the acid produced. The buffer effect of seawater is shown in Fig. 2, where pH is plotted against the quantity of sulfuric acid added.

Since seawater always contains sulfate ions in large quantities, obviously the likelihood of more pronounced variations in their concentration as a result of the exhaust treatment technique described is negligible.

Other exhaust components specified in Table 1 are also taken into consideration. The majority of dust is arrested by electrostatic precipitators prior to the scrubbing operations (Fig. 3). Part of the dust, however,

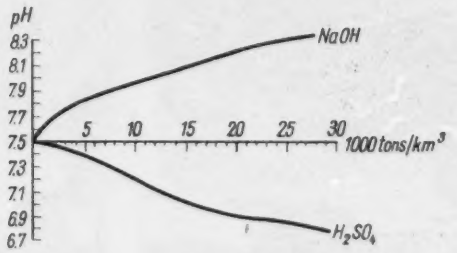

Fig. 2 Variations in pH value of seawater upon addition of the acid and the alkali.

Table 2

Some of the Components of Natural Seawater

Major components	Concentration in seawater g/kg	Minor components	Concentration in seawater
Chlorides (Cl^-)	19.98	nickel (Ni)	0.1–4 μg/l
Sulfates (SO_4^{2-})	2.65	vanadium (V)	0.3–7 μg/l
Bicarbonates (HCO_3^-)	0.14	dissolved oxygen (O_2)	0–14 mg/l
Boric acid (H_3BO_3)			
Sodium (Na^+)			
Magnesium (Mg^{2+})			
Calcium (Ca^{2+})			
Potassium (K^+)			
Strontium (Sr^{2+})			

Remark: The salt content of oceanic waters may vary over a wide range with respect to the average value of 3.5%. For instance, the Baltic waters exhibit low salt content, whereas the tropical lagoon waters contain much salt. However, the differences in salt content have no major effect on chemical properties of seawaters.

will be trapped by scrubbing liquor and discarded with the liquor to seawater. Depending upon the quantity and the manner this discharge is made, increased turbidity of seawater will take place in the discharge area. This enhanced turbidity is harmful, as the resultant increased light absorption may adversely affect the living conditions in definite regions of the sea.

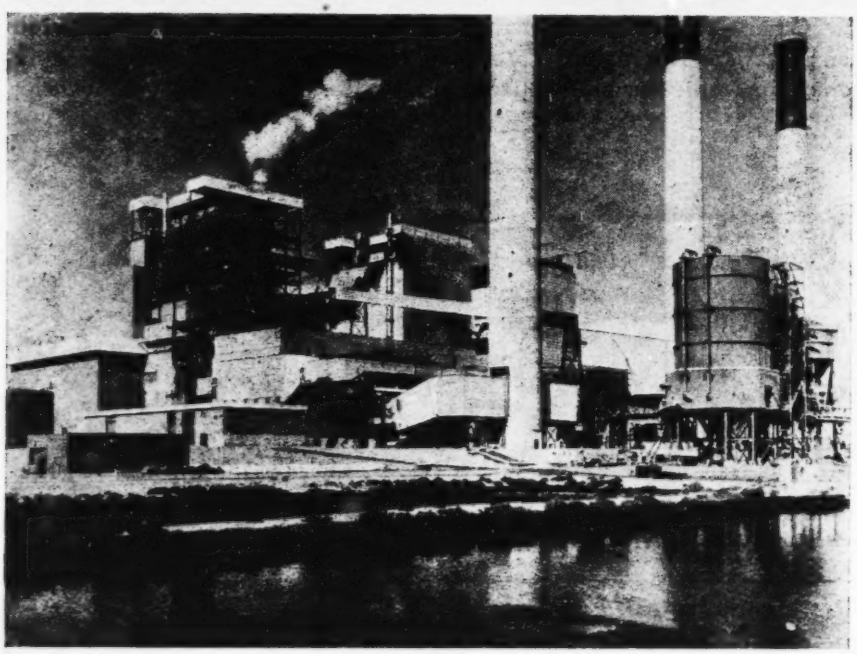

Fig. 3. A photograph of the Jem Bridger Power Plant, USA, equipped with electrostatic precipitators.

Much more dangerous is the presence of heavy metals in the effluents in view of the notable toxic activity of such metals. Some of them like mercury, chromium, cadmium, and zinc, if discarded with the effluents to sea, may become absorbed in biological processes. If introduced into living organisms in the nutritive cycle, they may, by means of successive enrichment, attain a toxic level. Other chemical elements like vanadium are not so hazardous, and they even can exert a favorable influence upon some marine organisms. The above findings must be considered in the selection of the effluent discharge point on seashore.

Carbon monoxide and oxides of nitrogen, which are also toxic products formed in the combustion processes, likewise pose a hazard. Haz-

ardous are also numerous organic compounds contained in exhausts which, when emitted into the atmosphere, are deleterious to both men and animals. This is particularly true of carcinogenic chemicals. However, the emission level of both organic compounds and the toxic gases mentioned can be controlled by proper run of combustion processes.

Conclusions

In considering the preventive measures toward excessive emission of contaminants produced during combustion of fossil fuels it can be said that one of the safest ways of exhaust treatment is their scrubbing with seawater and discharging of the effluents to sea. This procedure reduces, or even eliminates, the harmful side effects of the methods that involve dumping of the waste from pollution control equipment on land.

Prepared by K. J., based upon the article by E. Foyn of the Marine Biology and Limnology Institute of the Oslo University for Engineering in Britain Information Services

NEWS IN BRIEF

Resolution of the National Conference of the NOT Active Members Adopted on November 24, 1976

We, the participants of the National Conference of Polish Federation of Engineering Associations (NOT) which associates nearly half a million engineers, membres of scientific and engineering associations, want to express once again our firm support for the social and economic policy of the Party and the Government.

Resolutions of the 4th Plenary Session of the Central Committee of our Party defined the guidelines for a balanced and integrated approach in solving key problems. The tasks result from these resolutions for all the working people who are concerned about prosperity of our Country and her Citizens.

We are fully aware of our role and place in this nationwide social activity. We are also conscious of the tasks facing our NOT organizations. These organizations are to support and socially activate more efficiently the creative activity of engineers in the spirit of the motto "The Pole can do it" which we make it to be widely known and which has already been materialized in many instances in the practical activity of our engineers.

Our efforts will be the sign of our support for the decisions of the Party and the Government which aim at a further dynamic and balanced development of this Country. Our patriotic commitment will be expressed in terms of some economic effects of those efforts.

Participants of the conference agree that these efforts should be organized within the framework of programs of individual associations. For that reason we are addressing the NOT Main Council for the acceptance and assignment for elaboration of detailed plans and their accomplishment in conformity with the guidelines defined during our conference in the following trends and forms of activity:

1. A coordinative body composed of representatives of pertinent engineering associations, headed by a NOT Main Council member, should be created for each of the activity trends discussed in the report and con-

sidered during the conference proceedings, and related to such questions as: nutrition, building, export and market. The main task of the bodies will be the preparation with a deadline of January 31, 1977 of a detailed activity program for the tasks in the scientific, engineering and production fields. The body will appoint an association that would coordinate the work along a given line, and will assign the tasks among individual associations.

In preparing the programs attention should be given to the body of problems expounded in the program report and in the issues during the proceedings, and especially those presented by the Polish United Workers' Party Central Committee Political Bureau Member, Secretary comrade Jan Szydlak. Use should also be made of the proceedings of the pertinent congress bodies.

2. The following methods or forms of activity are recommended in the accomplishing of individual programs:

2.1. Scientific and engineering conferences and a variety of training forms planned for 1977 should match the problems comprised in detailed programs.

Priority should be given to these conferences and courses whose subjects are promising in the aspect of their immediate accomplishment of economic effects and progress.

2.2 Scientific and engineering publishers WCT NOT will, by the end of this year with the help of their Program Councils, prepare subject plans whose accomplishment will be helpful in solving main problems comprised in detailed programs on nutrition, market, building and export.

2.3 Engineering Associations, which are organizing or are going to organize contests for the best associations on the plant's level, will assume, as one of the criteria of their appraisal, the results of activity and coparticipation of the plant's associations in the accomplishment of the programs on nutrition, building, export and the market.

2.4 Main Board of the Engineering Associations and pertinent NOT committees should not fail to participate in the contests for the best products of the year.

2.5 The plant's associations should shape the inventive movement toward the solving of major engineering questions related to nutrition, market, building and export. The forms and scope of assistance for inventors should be extended in the social advisory groups.

2.6 The Engineering Associations' Expert Groups should place on their agenda the advisory work and expert's reports available for a variety of economic authorities for nutrition, market, building and export.

2.7 The existing system of awards of NOT and the associations should be used to honor individual inventors and groups, as well as social organ-

izers who substantially intensify the engineering achievements and economic effects.

2.8 Individual engineering associations should extend the scope of their Good Work movement and participation in that movement of engineers by means of their plant's committees, primarily in the plants in which production is related to problems of nutrition, market, building and export.

2.9 Presidiums of the NOT Main Council and the Main Board of the Scientific and Engineering Associations (SEA) in their international cooperation plans will give priority to the problems that may be of significance for the accomplishment of the nutrition, market, building and export program.

3. The NOT Main Council should ensure an ample and complete linking of the work on implementation of this resolution with the work of working groups of the party and government bodies appointed for the accomplishing of the resolution of the 4th Plenary Session of the Polish United Workers' Party Central Committee.

4. The Main Board of the Associations, the NOT Main Council and the Scientific and Engineering Association Plant's Committees or the NOT Plant's Committees should consult pertinent authorities to coordinate their activities with the whole of the undertakings in the field of nutrition, market, building and export. Much attention should be paid to these matters by the NOT and SEA units in 1976 and 1977.

5. Our programs will be treated as open. They can, and should be expanded and enriched with further creative initiatives by all the links of our movement. Accomplishments and updating of the nutrition, building, market and export programs should be on the agenda of the meetings of the Presidiums of the NOT Main Council, Main Board of SEA sections, committees and working groups.

6. The text of the program report delivered at the conference along with the opinions expressed by the conference participants should be published without unnecessary delay and widely distributed among the NOT units for further reference. This task should be entrusted to the Presidium of the NOT Main Council.

7. The NOT Main Council should charge the Organizing Committee of the 7th Congress of Polish Engineers with the wide use of the conclusions and findings resultant from the implementation of the provisions of this resolution in the work of the Congress Groups.

The conference participants express their belief that in the implementation of this program none of the engineers would be missing, and all the links of our movement fulfill their inspiring and organizing role. Thus, we appeal to the engineering communities with a deep conviction that in a joint effort we accomplish this program in full.

ANNOUNCEMENTS

International SECURA-78 Symposium

Scheduled for April 16 to 20, 1978 in Poznań is the SECURA-78 International Exhibit and Scientific Symposium on industrial safety.

During the Symposium, which is now being prepared, a number of events will be held on this subject, namely, International Exhibit of work safety engineering measures and equipment, research, control and measurement apparatus and instruments, personal protection, as well as promotional means in the domain of industrial safety: International Industrial Safety Film Review and International Industrial Safety Posters Exhibit.

The previous SECURA-75 Symposium was held in 1975 also in Poznań with a participation of representatives from science and practice from many countries, which are concerned with the industrial safety problems.

The Symposium is organized under the auspices of the Ministry of Labor, Wages and Social Affairs and the Central Council of the Trade Unions in cooperation with the Polish Academy of Sciences, Ministry of Science, Higher Education and Technology, the Ministry of Health and Social Welfare, and the Polish Federation of Engineering Associations (NOT).

The SECURA-78 Symposium is organized upon the agreement with International Labor Office and the International Social Security Association. The proceedings will be held in a plenary session and in two subject sections concerned with the following problems:

Section 1 — Prevention of the Chemical Process Hazards.

Section 2 — Prevention of the Works Transport Hazards and Hazards Involved in Work at Heights.

The Symposium languages (simultaneous interpreting): Polish, Russian, English, German. The proceedings will be published in Polish, Russian, and English.

Plenary Session

Reports:

1. Efficiency of the Prevention of Industrial Accidents and Occupational Diseases.

2. The Effect of Scientific and Technological Progress on Working Conditions.

3. Education of the Active Attitudes of Workers in the Creation of the Optimum Conditions of Man Protection in the Working Environment.

4. Fundamental Problems of Industrial Safety in the Production, Mechanization and Automation Process.

5. Effect of Standardization on the Progress in the Field of Industrial Safety.

Section 1. Prevention of the Chemical Process Hazards

1. Appraisal of the hazards appearing in the working environment:
— general problems and appraisals of working environment,
— appraisal of explosion and fire hazard,
— hazard appraisal in individual processes,
— hazard information system.

2. Prevention of hazards arising in chemical processes:
— elimination of hazards in the new process and equipment designing stage,
— engineering means for elimination of hazards with emphasis on explosion hazards,
— hazard minimalization techniques in the gas phase processes,
— storing of hazardous materials,
— disposal and utilization of hazardous waste.

3. Personal protection measures against chemical hazards:
— appraisal and the choice of materials used for personal protection, resistant to individual chemicals,
— proper selection of personal safety sets for individual workplaces,
— protection for respiratory ducts.

4. Preparation of a man for work:
— psychophysical and medical criteria of the selection of employees,
— training and adaptation of workers.

Section 2. Prevention of the Works Transport Hazards and Hazards Involved in Work at Heights.

1. Analysis of the hazard associated with works transport and with work at heights:
— vibrations and noise of means of transport,

— mechanical injuries and electric shocks in the operation and maintenance of the means of transport,
— drop of a load from a height,
— work at heights during maintenance of means of transport,
— hazards involved in modern storing and conveying techniques,
— effort associated with manual operations of load transfer.

2. Technological and organizational measures to improve working conditions in works transport and in work at heights:
— elimination of the hazards at the stage of designing and developing the work transport equipment;
— small-scale mechanization in works transport as a means to decrease the human effort,
— signalization and marking,
— lighting in the transport and conveyance operations,
— organization of operation, maintenance, and repairs to ensure safe working conditions,
— designs and equipping of the operator cabs and cages suited to the operating conditions,
— technological and organizational means to prevent the fall from a height.

3. Personal safety equipment of the works transport employees and those employed at heights:
— evaluation and selection of the materials for personal safety equipment,
— proper matching of the personal safety sets.

4. Human factors in works transport and in work at heights:
— psychophysical and medical criteria of the selection of workers,
— organization of training and training methods.

The proceedings will end on April 20, 1978.

Communications

Every participant may present one communication related to the subjects covered in the Symposium program. A summary of the communication alone should be submitted to the SECURA-78 Symposium Organizing Committee written in Polish, Russian or English (three copies) until October 1977. The summary should contain:
— title of communication,
— author's name,
— affiliation, city,
— purpose and main objective,
— description of the method used,
— results and conclusions.

The summary should not exceed two typescript pages (1500 strokes per page).

The time allowed for the delivery of full communication is 10 min. Communications may be illustrated with slides (5×5 cm), whose showing time should be included in the time allowed for the lecture.

The participation fee amounts to 600 zlotys. The communications and all the correspondence should be sent to the address: Sympozjum SECURA-78, Centralny Instytut Ochrony Pracy, 00-349 Warszawa, ul. Tamka 1, phone 26-34-21.

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